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Ontario Geological Survey
Open File Report 5704

Geology of the Horseshoe Lake Area District of Kenora (Patricia Portion)

1989

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Printed in Ontario, Canada

MINES AND MINERALS DIVISION

ONTARIO GEOLOGICAL SURVEY

Open File Report 5704

Geology of the Horseshoe Lake Area, District of Kenora (Patricia Portion)

by

L.S. Jensen

1989

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Jensen, L.S.

1989: Geology of the Horseshoe Lake Area, District of Kenora (Patricia Portion); Ontario Geological Survey Open File Report 5704, 140p., 7 tables, 10 figures, and 19 photos. Accompanied by maps P.3128 and P.3129 in back pocket.

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90-02203/

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Preface

Until 1987 the geological map coverage of the Horseshoe Lake Area in the District of Kenora was at a reconnaissance level. The present detailed mapping project was designed to encourage mineral exploration and to provide a mineral potential evaluation and a data base for land use planning.

The Precambrian bedrock of the area hosts several auriferous, minor sulfide occurrences. The author describes several potential gold environments such as shear zones, quartz-K-feldspar porphyry dikes, and units of sulfide-bearing clastic metasedimentary rocks and iron formation, that occur in the area of investigation.

V.G.Milne
Director
Ontario Geological Survey

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ABSTRACT

The Horseshoe Lake Area is 475 km2 in size and located about 100 km north-northwest of Pickle Lake, Ontario. It is bounded by Latitudes 52°07'30" and 52°15'00"N and Longitudes 90°30' and 91°00'W. Archean rocks, overlain by unconsolidated Cenozoic glacial and fluvioglacial deposits, forms the geology of the area.

The Archean supracrustal rocks form a belt (known as the Horseshoe Lake Greenstone Belt) in the southern part of the Sachigo Subprovince within the Superior Province of the Canadian Shield. Gneisses encompass the supracrustal rocks. The belt forms a 30 km by 8 km east-trending metavolcano-sedimentary sequence comprised of 4 fault-bounded, interleaved geological domains whose relative ages remain uncertain. The 4 domains consist of supracrustal rocks of distinct lithologies, metamorphic grade, and structure, bordered by gneisses interpreted by the author to be of the same protolith.

The domains are defined as:

1) The Southern Domain, comprised of lower amphibolite grade arkosic metaconglomerate, wacke, and siltstone.
2) The Central Domain comprised of middle to upper greenschist grade tholeiitic basalts inter-layered with quartz-rich conglomerate, wacke, arenite, siltstone, mudstone, chert, iron-formation and limestone.
3) The Northern Domain comprised of middle to upper greenschist grade quartz-rich sedimentary rocks as found in the Central Domain interlayered with subordinate tholeiitic basalts.

4) The Calc-alkalic Domain comprised of lower greenschist grade calc-alkalic basalt, andesite, dacite and rhyolite flows and tuffs with interlayered iron formation. A few subvolcanic rocks intrude the metavolcanic rocks.

The Northern and Central Domains originally possibly were parts of one geological terrain. The other domains, however, were deformed and metamorphosed independent of one another prior to the development of the enclosing tonalitic granitoid gneisses and the tectonic juxtapositioning of all the rocks along east-trending fault zones. At the margins of the Horseshoe Belt, the supracrustal rocks of the greenstone assemblage were subjected to strong metamorphism and migmatization. Most of the domains exhibit signs of two phases of deformation and one period of metamorphism prior to the migmatization at the margin of the belt.

Late K-rich granitoid batholiths and pegmatites were emplaced into the tonalitic gneisses south of the Horseshoe Greenstone Belt and caused wide-spread K-metasomatism in the gneisses. A few K-rich granitoid dikes and stocks also intruded the supracrustal rocks but did not cause wide-spread K-metasomatism.

During the late stages of K-rich granitoid rock emplacement, or possibly later, additional deformation occurred along east-trending fault zones located along the domain boundaries within the belt, along the margins of the belt and along wide zones in the granitoid gneisses. Subvertical, right-lateral displacement accompanying this late stage deformation, caused the domains to

be transposed into their present configuration and to undergo some additional internal brittle deformation mainly in the form of east-northeast trending faults. Alteration such as carbonatization accompanied the deformation in places.

Gold, arsenopyrite, chalcopyrite and pyrrhotite in association with pyrite form gossans in the area. The highest gold values were obtained from shear zones associated with the late east-northeast trending brittle faults and in and near late K-feldspar porphyry dikes found at the nose of an anticline in the Central Domain. Other east-northeast trending faults located away from the nose of the anticline also yielded anomalous gold values as did pyrite bearing sheared calc-alkalic tuffs on the south margin of the Calc-alkalic Domain. Some prospecting has been carried out near the nose of the anticline in the Central Domain and along sulphide-bearing zones of iron formation in the Calc-alkalic Domain.

GEOLOGY OF THE HORSESHOE LAKE AREA DISTRICT OF KENORA (PATRICIA PORTION)

by

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Manuscript approved for publication by V.G. Milne, Director, Ontario Geological Survey.

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GEOLOGY OF THE
HORSESHOE LAKE AREA
District of Kenora (Patricia Portion)

INTRODUCTION

Location and Access

The Horseshoe Lake area encompasses the Horseshoe Greenstone Belt; an Archean metavolcano-sedimentary belt surrounded by granitoid rocks within the Superior Province of the Canadian Shield.

The Horseshoe Lake area lies between Latitudes 52°07'30" and 52°15'00"N and Longitudes 90°30' and 91°00'W in the Patricia Portion of the District of Kenora, Ontario. The area is 34.2 by 13.9 km (475 km2) in size and located 100 km north-northwest of Pickle Lake within the Patricia Mining Division.

The Horseshoe Lake area is accessible by float-equipped aircraft on Horseshoe, Kecheokagan and Wapamisk Lakes. Highway No.808 extends north from Pickle Lake to Windigo Lake and transacts the eastern end of the Horseshoe Lake Greenstone Belt, 160 km north of Pickle Lake. From the road, boats may be launched on the Pipestone River, which permits access to Horseshoe Lake and Kecheokagan Lake.

The purpose of this report is to provide a detailed geological data base and a better understanding of the geology for mineral exploration. Both base-metal and precious-metal mineralization have been reported in the area (Carruthers, 1961; Sage and Breaks, 1982).

Physiography

Relief in the map area is about 15 m and the mean elevation decreases from about 380 m above sea-level in the south-west corner of the map area to about 360 m in the northeast part of the map area. Relief is gentle and caused largely by glacial deposits modified by recent weathering and erosion. Relief becomes more varied in areas where numerous bedrock highs are exposed.

Drainage is to the north-northeast by the Pipestone River System through Kecheokagan and Horseshoe Lakes. The Pipestone River is joined by the Morris and North Pipestone Rivers which flow into Kecheokagan Lake and by Wapamisk Creek which flows into Horseshoe Lake. Numerous other smaller tributaries, some of which are cancoeable, also join the Pipestone River System. In most areas, because of the gentle relief, drainage is poor.

Bedrock exposure is abundant in the northwest quarter of the map area and consists of Archean metavolcanic and metasedimentary rocks that grade, northward, into granitoid gneisses (see maps and , in back pocket). Outcrop becomes sparse and unevenly distributed in the south half of the map-sheet underlain by granitoid gneisses and plutonic rocks. In the northeast part of the area, bedrock is thickly mantled by the Agutua Morain (Prest, 1963) and consequently, less is known about the bedrock underlying the eastern portions of the Horseshoe Lake area.

Previous Geological Work

In 1960, the Geological Survey of Canada mapped the Horseshoe Lake area as part of a large project that included North Caribou Lake (Carruthers, 1961). This survey aided by aeromagnetic maps (ODM-GSC, 1960), indicated the presence of a metavolcano-metasedimentary succession in the vicinity of Horseshoe Lake within a largely granitoid terrain. Pillowed lavas, clastic metasedimentary rocks, iron-formation in addition to gold mineralization were noted during the 1960 investigations to occur in the metavolcano-metasedimentary succession.

In 1972, the Ontario Geological Survey conducted a helicopter supported reconnaissance survey in the Pickle Lake area which included the Horseshoe Lake area (Sage and Breaks, 1982). The survey indicated metagabbroic rocks formed a large part of the metavolcano-metasedimentary succession in addition to the lithologies noted by Carruthers (1961).

Since 1960, additional geological information has come from various mining exploration companies in search of base and precious metals. Much of this work focused on small claim groups staked on the basis of localized sulphide mineralization and geophysical anomalies.

Present Geological Survey

Field mapping was conducted in the summer of 1987. Maps P and (back pocket, scale 1) presents the results of the geological survey carried out by the author and his field assistants at a scale of 1 inch to 1/4 mile (1:15 840). Vertical aerial photographs at a scale of 1 inch to 1/4 mile (1:15 840)

were supplied by the Air Photo Library, Public Information Centre, Ontario Ministry of Natural Resources and used for mapping control. Acetate overlays were used to record data that were collected on traverses run by the pace and compass method. Information from mapping was transferred to Forestry Inventory Resources base maps 522904 and 522903 at a scale of 1:15 840 supplied by the Surveys, Mapping and Remote Sensing Branch, Ontario Ministry of Natural Resources.

Geology was not tied to surveyed lines; instead, land marks such as shore lines, small lakes and streams were used to tie in the geology by pacing and compassing. Traverses were designed to include as much outcrop area as possible particularly in areas of complex geology and along contacts between major rock units. In areas containing limited outcrop, traverses were at wider spaced intervals and aimed specifically at land formed features that might contain bedrock exposures not readily visible on aerial photographs.

Acknowledgements

The writer was ably assisted during the field preparations and field mapping by Robert Fogal as senior assistant. Assistance was also provided by Christopher Hibberd, John Paul Jordan and Thomas Brockelbank. The assistance of various staff members of the Fire Control Office, Ministry of Natural Resources Pickle Lake is greatly appreciated as is the administrative support provided by the Sioux Lookout District Office, Ministry

of Natural Resources and by the Resident Geologist's Office, Ministry of Northern Development and Mines.

Air support services were provided by Central Air Transport and Kelnor Airway Limited out of Pickle Lake.

Discussions with my colleges R.P. Sage, F.W. Breaks, I. Osmani, P.C. Thurston and G.M. Stott proved useful. Their previous experience in this part of the Superior Province was a valuable asset.

GENERAL GEOLOGY

The Horseshoe Lake area is located in the south part of the Sachigo Subprovince of the Canadian Shield (Figure 2). The area contains one of several narrow widely spaced curvilinear volcano-sedimentary belts within the Sachigo Subprovince separated from one another by massive to gneissic granitoid rocks. Many of these belts of supracrustal rock contain ultramafic to mafic metavolcanic rocks interlayered with metasedimentary rocks (Thurston et al. 1987). Units of quartz arenite, and carbonate in many of these successions suggest that they may represent platformal, shallow-water successions.

The greenstone belt at Horseshoe Lake is considered to be the most southerly greenstone belt in the Sachigo Subprovince and considered to be located at the contact of this province with the largely granitoid Berens River Subprovince to the south (Figure 2). The Horseshoe Belt is one belt in a chain of greenstone belts more or less arranged in a circle that is approximately 80 to 100 km in diameter and that encloses an area underlain by

granitoid rocks. The other belts occur to the northwest at Windigo Lake (Satterly, 1941) and to the north and northeast at Eyapamikama and Opapimiskan Lakes (Breaks et al. 1985).

The Horseshoe Lake Greenstone Belt is comprised of four geological domains named by the author the Southern, Central, Northern and Calc-alkalic Domains (Figure 3). Major subvertical shear zones form the contacts between the domains. Along these zones, right lateral displacement occurred.

The Southern Domain on the south side of the belt consists of arkosic metasedimentary rocks deposited as turbidites. This succession is formed by several 10 to 50 m thick sedimentary cycles that have sharp contacts with the underlying rocks and begin with monomictic, matrix supported conglomerate and fine upward into beds of wacke that are followed upwards by siltstone. These rocks have undergone folding and lower amphibolite grade metamorphism and grade southward into paragneiss.

The Central Domain is in fault contact with the Southern Domain to the south and the Northern and Calc-alkalic Domains to the north. This domain comprises a metavolcano-metasedimentary succession folded about an overturned, steeply plunging anticline in which the rocks are of middle to upper greenschist metamorphic rank. The metasedimentary rocks are quartz-rich and grade up in the succession from polymictic conglomerates into wackes, arenites, siltstones and mudstone which in places are associated with magnetite-rich wackes, chert, iron formation and limestone. They form thick units, particularly near the top of the succession, as well as thin interflow layers that are

interlayered with tholeiitic metavolcanic units. The metavolcanics of the Central Domain comprise mainly massive flows of Mg-rich to Fe-rich tholeiitic basalts and minor tholeiitic andesite, dacite and rhyolite.

The Northern Domain also comprises quartz-rich units of wacke, arenite, siltstone, mudstone, chert and minor iron formation which have undergone middle to upper greenschist metamorphism. Subordinate units of tholeiitic metabasalt occur with the metasedimentary rocks.

The Calc-alkalic Domain, which has undergone lower greenschist metamorphism, is comprised of massive to pillowed calc-alkalic basalts and andesite and low iron Mg-rich tholeiitic basalt. Tuffs of calc-alkalic basalt to rhyolite composition interbedded with iron formation and graphitic mudstone occur with the flows. The calc-alkalic metavolcanic rocks are cut by subvolcanic gabbros, anorthositic gabbros and feldspar and quartz feldspar porphyries that have calc-alkalic chemical affinities.

The intrusive rocks which, in addition to the calc-alkalic subvolcanic rocks, cut the Horseshoe Greenstone Belt internally, comprise a small trondhjemite stock and a granodiorite stock. Late mafic dikes, perthite- and quartz-perthite-phyric dikes, and lamprophyre dikes also cut the supracrustal rocks, mainly in the Central Domain.

External intrusive rocks to the Horseshoe Greenstone Belt are comprised of granitoid gneisses which according to protolith form 4 groups. They consist of gneisses of metasedimentary, tholeiitic and calc-alkalic metavolcanic and mixed sedimentary-

volcanic-tonalitic protoliths. These gneisses form distinct units both north and south of the greenstone belt proper. South of the belt they are intruded by early gneissic granitoid rocks and late K-rich massive to pegmatitic granitic rocks. Extensive K-metasomatization of the gneiss accompanied the emplacement of the late K-rich granitic rocks.

During the late stages of K-granitoid rock emplacement, deformation occurred along east-trending fault zones located along the domain boundaries, near the margins of the belt and within the external gneissic terrains. Many of the fault zones represented earlier formed zones of weaknesses. Subvertical movement with some right-lateral displacement occurred along these fault zones during this late deformation, caused the domains and groups of gneissic rocks to be transposed into their present configuration and the domains to undergo some internal brittle deformation.

Late north-northwest trending diabase dikes cut all the rocks and structure.

Lithologic units for the Horseshoe Lake area are shown in Table 1. The grouping of the rocks is strictly lithologic and does not imply stratigraphic order as geochronological relationships between the geological domains remain uncertain. For example, the metasedimentary rocks of the Southern Domain may represent the oldest group of rocks because of their highest grade of metamorphism and are not likely equivalent to those metasedimentary rocks found within the Central, Northern or Calc-alkalic Domains.

METASEDIMENTARY ROCKS

(Unit 1)

Introduction

Metasedimentary rocks occur in all four geological domains of the Horseshoe Greenstone Belt. They are metaclastic rocks deposited as turbidites associated with subordinate chemical metasedimentary rocks such as iron-formation, chert, graphitic metasediments and impure limestone. The metaclastic metasedimentary rocks also occur as remnants in the external granitoid gneisses and were much of these gneisses are believed by the author to have been derived from these metasedimentary rocks.

In the Southern Domain, the metasedimentary rocks are arkosic metaclastic rocks that comprise 10 to 50 m thick, sedimentary cycles. These cycles begin with beds of monomictic, matrix supported conglomerate that have sharp contacts with the underlying rocks and fine upward into beds of wacke, siltstone, and mudstone. Metavolcanic rocks are absent in this sedimentary succession of the Southern Domain.

In the Central Domain, the metasedimentary rocks are quartz-rich, plagioclase-poor, clastic rocks in contrast to the metasedimentary rocks of the Southern Domain. These clastic rocks consist of polymictic conglomerate, wacke, arenite, siltstone and mudstone. Lesser amounts of quartz-arenite, magnetite-rich wacke and arenite, and fuchsite-bearing siltstone and mudstone, as well as minor chert, iron formation, and impure

limestone are present. The clastic rocks are interlayered with mafic tholeiitic metavolcanic rocks, and in places, thin zones of felsic calc-alkalic metavolcanic rocks. The metasedimentary rocks occur as thin interflow sediments and as thicker, more diverse metasedimentary units which show upward fining and maturation. The ratio of metasedimentary rocks to metavolcanic rocks in the Central Domain decreases from 1:1 north of Kecheokagan Lake, in the western end of the belt to less than 1:20 south of Wapamisk Creek and Lake in the eastern end of the belt.

In the Northern Domain, the metasedimentary rocks are similar to the more mature metasedimentary rocks of the Central Domain except that they predominate over the mafic tholeiitic metavolcanic rocks which make up only 10 to 15 percent of the domain. The metasedimentary rocks of the Northern Domain tend to be more strongly deformed than those of the Central Domain.

Metasedimentary rocks form only a minor part of the Calc-alkalic Domain. They are sulphide and oxide facies iron formation and chert that, in places, are associated with calcareous mudstone and siltstone and graphitic mudstone. The iron-formation is largely restricted to the tuffaceous portions of the calc-alkalic metavolcanic succession.

Chemical analyses were completed on 13 hand specimens; all from the metasedimentary rocks of the Central Domain. Table 2 contains analyses from the thick metasedimentary units and includes the sample BA described as a dacite by Sage and Breaks (1981). Table 3 contains 3 analyses from interflow

metasedimentary layers, 4 analyses from magnetite-bearing wackes and arenites and 1 analysis of impure limestone (S13). The locations from where the analyzed samples were obtained are indicated on map (back pocket).

The metasedimentary rocks have a greater alkali content than do the metavolcanic rocks, in particular K_2O. The magnetite-bearing wackes and arenites are distinguished by their high Ti, P_2O_3, Y and Zr contents. The impure limestone has a low silica content and has 50 percent CIPW normative calcite.

Metasedimentary Rocks of the Southern Domain

The metasedimentary rocks of the Southern Domain are a distinctively arkosic suite of conglomerates, wackes and siltstones. These metasedimentary rocks are not interlayered with metavolcanic rocks and, thus, form the only suite of supracrustal rocks in the Southern Domain. Their best exposures occur along the south shore of the Pipestone River east of Kecheokagan Lake. They form a succession of several 10 to 50 m thick, sharp-based sedimentary cycles that begin with beds of monomictic, matrix-supported conglomerate, and fine upward into beds of wacke that are followed by siltstone beds. The rocks were deposited as turbidites. They strike 060° and dip 80° to 90° to the southeast. In the east part of the Southern Domain, the strike of the beds becomes 115° with 80° to 90° dips to the east.

As the metasedimentary rocks of the Southern Domain grade southward into east-trending micaceous paragneisses. Farther to

the south, about 0.5 km from the southern Domain proper, these paragneisses appear to be truncated by faulting against more mafic hornblende-bearing orthogneisses. Granitoid mobilizate cuts both the paragneisses and the hornblende orthogneisses. On the north side of the Southern Domain, the metasedimentary rocks do not extend to the north shore of the Pipestone River. Instead, they appear been truncated under the river against the metavolcanic and metasedimentary rocks of the Central Domain (Figure 3).

The metasedimentary rocks of the Southern Domain have been affected by regional lower amphibolite grade metamorphism. As a consequence their primary mineralogy, textures and bedding feature have to be modified and no microscopic relict primary detrital textures remain. Only megascopic primary features such as grain-size gradations, pebble-size gradations, and bedding contacts can be recognized on outcrops and can be used to determine younging directions. The rocks range from biotitic schists to quartz-biotite-feldspar gneisses.

All the sedimentary rocks have a lepidoblastic texture and are comprised of biotite, plagioclase (albite to andesine) and quartz. Subordinate amounts of microcline and epidote occur, and accessory magnetite, apatite and garnet are present. Hornblende occur in the cores of some epidote grains, and in some rocks, 4 to 6 mm xenoblasts of plagioclase contain numerous 0.1 to 1 mm size laths of biotite. In this group of metasedimentary rocks, quartz is subordinate in abundance to biotite and plagioclase and

occurs with a granoblastic texture interstitial to the plagioclase and biotite.

The conglomerate units at the base of each sedimentary cycle contain stretched subrounded cobble-to pebble-sized clasts which are more resistant to weathering than the matrix and give the outcrops a knobby appearance. The clasts have a more plagioclase and are slightly coarser grained than the matrix. They are deformed, disk-like parallel to the foliation of the rock and have a thickness:length:width ratio of approximately 1:10:2. On fresh surfaces, the clasts and matrix are difficult to distinguish from one another. In most conglomerate units, the clasts decrease in size and number toward the tops of individual 0.5 to 3 m thick beds. Toward the top of the conglomerate units the clasts are smaller than in the more central and lower portions of the units and the conglomerate grade into wackes.

In middle portions of each sedimentary cycle are beds of arkosic wackes from 0.1 to 10 m thick. Many beds consist of massive, 3 to 4 mm grained, light grey rocks that are gneissic in appearance. Other beds are finer grained, darker in colour and more biotite rich. They show upward-fining grain gradation in the plagioclase.

In the upper siltstone unit of the sedimentary cycles, the beds tend to be fine grained, schistose, dark grey to green to black, biotite-rich, and 0.01 to 0.5 m thick. Some beds that are lighter grey and have slightly coarser and more abundant plagioclase and quartz, are interlayered with the biotite-rich beds. At the top of the cycle, where the uppermost siltstone

beds are located, a sharp contact occurs with the overlying thicker, coarser, pebble-bearing conglomerate beds which form the base of the next sedimentary cycle.

The metasedimentary rocks of the Southern Domain are more limited in composition than those of the Central and Northern Domains which suggests their provenance was more restricted and possibly different from that of the Central and Northern Domains. The metasedimentary rocks were likely derived from unknown feldspar-rich sources by mechanical and chemical degradation. No indicators of a volcanic provenance were found in the metasedimentary rocks.

Metasedimentary Rocks of the Central Domain and Northern Domain

Distribution

The metasedimentary rocks in the Northern Domain are mainly wacke, arenite, siltstone, mudstone and chert similar to those at the top of the metavolcano-sedimentary succession of the Central Domain. In the Central Domain, the metasedimentary rocks are part of a 3.5 to 4 km thick folded volcano-sedimentary succession. The ratio of metasedimentary rocks to metavolcanic rocks decreases from greater than 1:1 north of Kecheokagan Lake, in the western part of the domain, to less than 1:20 near Wapamisk Lake in the eastern part of the domain (Map , back pocket).

The metasedimentary rocks of the Central Domain comprise metamorphosed conglomerate, wacke, arenite, siltstone and mudstone, all of which were deposited as turbidites.

Metamorphosed chert, limestone and banded iron formation also occur. The clastic metasedimentary rocks form thick units (50 to 500 m) that extend along strike for several kilometres (Figure 3), and thin (<3 m) interflow layers within the tholeiitic units which are shown as dotted lines within flow units on the accompanying map (back pocket). Many of the thick metaclastic units contain subordinate, thin flows of tholeiitic basalt shown as hachures within the metasedimentary units on the maps (P , Back Pocket).

The thick metasedimentary units display an upward progression from pebbly wacke to mature quartzo-feldspathic arenite and quartz arenite. This progression is observed both within thick individual units and throughout the entire volcano-sedimentary succession, i.e. the upper units in the succession, in general, are more mature than the lower ones. Two polymictic, matrix-supported pebble to boulder conglomerates with interlayered tholeiitic basalt comprise the lowermost metasedimentary units of the succession (Figure 3). The lower of these two conglomerates has a mafic volcanoclastic matrix supporting clasts of white, pumiceous to massive calc-alkalic rhyolite, chert, and a variety of other sedimentary and mafic volcanic rocks. The upper conglomerate has a more mature, sandy matrix with clasts of mafic to felsic volcanic rocks and chert, and rip-up clasts of conglomerate, wacke and fuchsite-rich, cherty siltstone. Conglomerate is absent from the stratigraphically higher metasedimentary units, and the coarsest metasediments are pebbly wackes and arenite that grade up into

thick subunits of finer-grained wacke, arenite, siltstone and mudstone. In the highest units, quartz arenite and chert beds are locally abundant.

The chemical metasedimentary rocks in the Central Domain consist of chert, iron formation and a 1 m thick bed of recrystallized limestone. Iron formation, commonly containing pyrite and pyrrhotite, occurs within some interflow sedimentary units, as well as within the lowermost conglomerate in the lower half of the volcano-sedimentary succession. In the upper half of this succession, the iron formation is interlayered with siliceous mudstone and chert, and in most places is less than 1 m thick. Chert, with or without associated iron formation, is best developed in the upper half of the succession, within some thick metasedimentary units that contain arenite. Ferruginous beds of quartz arenite and chert also occur in the upper portions of the volcano-sedimentary succession in the Central Domain.

In the Central and Northern Domains, the metasedimentary rocks have been affected by middle to upper greenschist metamorphism. They retain their original clastic textures as well as primary bedding features. Only where the metasedimentary rocks grade into paragneisses are their textures lost due to lower amphibolite metamorphism. However, most of the metasedimentary rock have undergone regional deformation as shown by the less competent clasts and beds. Along the major shears near the boundaries of the Northern Domain, the metasedimentary rocks become mylonites, in which clastic quartz grains become elongated several times their original size.

Metaconglomerate Units

Three separate units of metaconglomerate occur north of the northwest end of Kecheokagan Lake, two of which can be followed eastward for approximately 7.5 km. In this report, the two traceable units of metaconglomerate are referred to as the Lower and Upper Conglomerates Units. The third metaconglomerate unit either rapidly thins out, or becomes part of the Upper Conglomerate Unit that can be traced eastward. Below the metaconglomerate units, to the south, no other thick metasedimentary units were observed within the metavolcano-sedimentary succession of the Central Domain. Only a few thin interflow metasedimentary layers occur within the underlying tholeiitic volcanic rocks. At the northwest end of Kecheokagan Lake, mesocratic quartz-hornblende-feldspar gneiss extends as far north as the Lower Conglomerate Unit. Elsewhere, to the east and west, the Lower Conglomerate Unit rests on a unit of Mg-rich tholeiitic basalt. Above the conglomerates are additional units of tholeiitic metavolcanic rock with subordinate interflow metasedimentary rocks.

The Lower and Upper Conglomerate Units have their greatest thickness and best exposures north of the northwest end of Kecheokagan Lake. To the northwest, the metaconglomerates quickly thin and disappear or grade into wackes. Eastward, the two metaconglomerate units gradually thin and subunits of iron-formation occur in the Lower Conglomerate in its eastern extent. The Upper Conglomerate appears to grade into pebbly wackes and

arenites toward the east before it disappears. The distribution of the metaconglomerate units and their variation in thicknesses and facies changes suggest that they were part of a volcano-sedimentary succession deposited near the margin of a basin that gradually deepened towards the east.

The Lower Conglomerate is a schistose, polymictic, matrix supported pebble to boulder conglomerate. The matrix contains abundant 0.1 to 1 mm size, subparallel grains of biotite and actinolite-tremolite which give the metaconglomerate its dark grey to dark green colour. These mafic minerals are mixed in varying proportions with subrounded to subangular, 0.5 to 2 mm sized quartz and altered plagioclase. Scattered rectangular plagioclase and bipyramidal quartz crystals that were possibly derived from felsic volcanic sources also occur in the matrix.

The clasts in the Lower Conglomerate comprise rip-up clasts, felsic volcanic clasts and mafic volcanic clasts. Except for some of the more competent felsic and large mafic metavolcanic clasts, the clasts are stretched subparallel to bedding 3 to 10 times their original size. Clasts of a particular lithology and size-range tend to be concentrated in specific layers.

The rip-up clasts range in composition from a biotite-tremolite rock similar to that of the matrix of the conglomerate to fine-grained, grey siliceous metasiltstone and metamudstone. Some clasts are more arenaceous. The rip-up clasts are concentrated in specific layers in which they are all of similar size. The layers vary from beds 1 cm thick with 2 mm disc-shaped clasts to 3 m thick beds with clasts as large as 24 cm by 20 cm.

Some beds have rip-up clasts of conglomerate which in turn, include rip-up clasts and other clast types found elsewhere on the outcrop. Although, rip-up clasts represent the most abundant clast type in the Lower Conglomerate, they are difficult to recognize except on clean weathered surfaces.

The felsic volcanic clasts comprise white, massive, subrounded, 0.5 to 20 cm sized rhyolite fragments and curvilinear, light grey, collapsed, pumice fragments 2 to 20 cm long. The massive rhyolite fragments consist of fine-grained to 1 mm grained, interlocking grains of plagioclase and quartz. Some of the rhyolite fragments have quartz phenocrysts and some have a schistose to gneissic fabric. Within the pumice fragments, the amygdules are needle shaped and are filled with fine-grained milky to clear glassy quartz. The felsic volcanic clasts may have had a source similar to that of the subhedral to euhedral quartz and plagioclase crystals found in the matrix of the conglomerate.

The mafic volcanic clasts are dominantly subrounded, stretched, cobble to pebble sized and dark green to black. They are similar in composition to the fine-grained portions of the tholeiitic metabasalt flows that are interlayered with the conglomerates. Changes in abundance and size-range of these clasts occur between subunits and beds within the Lower Conglomerate.

The Upper Conglomerate Unit, in contrast to the Lower Conglomerate Units, has a more mature, quartz-rich wacke matrix. However, subordinate subunits of metaconglomerate with a mafic

matrix similar to that of the Lower Conglomerate Unit, do occur toward the base of the Upper Conglomerate Unit. In the Upper Conglomerate Unit where the matrix is most quartz-rich, both large and small scale graded bedding and channel scouring and filling show north-topping directions (Photo 1). Where the matrix has a sandy light grey appearance, it consists of 35 to 65 percent strained, subrounded, 0.1 to 1.5 mm sized quartz grains of detrital origin surrounded by lepidoblastic biotite and muscovite laths 0.01 to 1 mm long. The micas have interstitial quartz and albite present and in places are associated with tremolite and magnetite. Minor detrital grains of magnetite, pyrite and altered plagioclase occur with the quartz grains. Euhedral to subhedral quartz and plagioclase crystals of possible felsic volcanic origin are rarer than those in the Lower Conglomerate, and instead, the matrix of the Upper Conglomerate is more similar to wackes located higher in the metavolcano-sedimentary succession.

Near the top of the Upper Conglomerate Unit, the beds of metaconglomerate become interlayered with thin (1 cm to 1 m thick) beds of quartz-rich meta-wacke,-siltstone and -mudstone. In the darker coloured, more mafic mudstone layers, porphyroblastic garnet 0.1 to 2 mm in size is developed. Other layers are light to intense emerald green coloured siltstones and mudstones that contain fuchsite.

The Upper Conglomerate Unit, contains are rip-up metasedimentary, felsic metavolcanic and tholeiitic metabasalt clasts similar to those observed in the Lower Conglomerate. In

addition, subunits containing numerous chert, quartz, and fuchsite-bearing siltstone pebbles occur in the middle and upper parts of the unit. The rip-up clasts range up from mm size to meter size and, except for the chert and quartz pebbles, are representatives of less disturbed sedimentary rock elsewhere in the Upper Conglomerate. Many of the larger rip-up clasts are locally derived conglomerate which also contain rip-up clasts. Many of the rip-up conglomeratic clasts are only recognizable where their matrix or suite and proportion of clasts differ from that of the host subunit. Most of the larger tabular-shaped rip-up clasts have undergone stretching and micro-to megascopic faulting subparallel to bedding such that they have jagged ends but smooth convex to straight upper and lower surfaces. Many of the less competent wacke, siltstone and mudstone clasts are smaller and more strongly stretched than the conglomeratic clasts.

Both massive and pumiceous felsic metavolcanic clasts of dacitic to rhyolitic composition occur in the Upper Conglomerate but are less common than in the Lower Conglomerate Unit. As well, the mafic tholeiitic metavolcanic clasts form an important proportion of the clasts in the Upper Conglomerate Unit. Most of these clasts are dark green to black, fine grained, subrounded, .5 to 10 cm in their maximum dimension and range from weakly to strongly stretched (Photo 2).

Pebble-to cobble-sized, white to grey to black chert, and glassy quartz clasts as well as stretched emerald green fuchsitic siltstone clasts are sparsely distributed throughout the Upper

Conglomerate except toward its top. Here, these clasts are segregated and concentrated in single beds up to a meter thick.

In both the Upper and Lower Conglomerate Units, sulphide clasts that range from granule to pebble size are present but not very common. Although sulphide layers in the form of pyrite and pyrrhotite occurs with the iron formation in the eastern part of the Lower Conglomerate, clasts of these rock types are absent in the conglomerates towards the west which suggests the direction of transport may have been from west to east. Because regional deformation has affected many beds and modified the primary sedimentary features such as imbrication, paleo flow indicators are difficult to use with certainty in determining transport directions.

Metawacke, -arenite, -siltstone and -mudstone Units

The metasedimentary rocks stratigraphically above the metaconglomerate units in the Central Domain form 5 to 600 m thick composite units of interbedded wacke, arenite, siltstone and mudstone and, in places, chert. These units are interlayered with tholeiitic metavolcanic units. They are distinguished from the thinner, less mature, more homogeneous, layers of interflow metasedimentary rocks by their greater content of detrital quartz and lower content of mafic minerals. Within most units, the wackes and arenites repeatedly grade upward into siltstone both within single beds, and over several beds. The thickest and best developed of these metasedimentary units occur near the top of the metavolcano-sedimentary succession of the Central Domain

beginning about 2.7 km north of Kecheokagan Lake. These units are traceable for more than 15 km whereas many of the lower, thinner units have strike lengths of less than 1 km.

Approximately 80 percent of the metasedimentary rocks are metawackes, -arenites, -siltstones and mudstones. They are typically grey to light grey rocks with light brown to grey weathered surfaces. Although most of these rocks have undergone upper greenschist facies metamorphism accompanied by various amounts of structural deformation, they tend to retain relict sedimentary textures. Individual clear to milky white quartz and plagioclase grains embedded in a finer-grained micaceous matrix can be observed on the weathered surfaces and in thin section. The remaining 20 percent of these metasedimentary rocks are pebble wacke, magnetite-bearing wacke and arenite, quartz-arenite and fuchsite-bearing siltstone.

The more common metawackes, -arenites, -siltstones and -mudstone, are distinguished from one another only by the size and abundance of detrital quartz and plagioclase. In all the rocks detrital plagioclase grains are mainly albite and oligoclase, which have the same size distribution as the quartz but are less abundant than quartz. The ratio of plagioclase quartz is less than 1:10. In most rocks, the detrital quartz and feldspar grains are angular to rounded and supported by a micaceous quartzo-feldspathic matrix (Photo 3). In most rocks, the plagioclase is twinned and has cloudy alteration. Quartz is strained. The surfaces of the plagioclase and quartz clasts are

penetrated by micron-sized laths of mica to suggest some reaction between the matrix and clasts has occurred during metamorphism.

In the wackes, quartz and plagioclase clasts form 30 to 60 percent of the rock. These clasts are poorly sorted according to size and tend to have an uneven distribution. The clasts in the coarser wackes range from 0.1 to 6 mm and in the finer grained wackes, from 0.1 to 1.5 mm. A few clasts of altered siltstone, mafic rock and quartzo-feldspathic rock, 1 to 5 mm in size, occurs in some of the coarser wackes. The matrix enclosing the clasts forms a lepidoblastic texture and is comprised of biotite and muscovite in various proportions with interstitial quartz and albite and embedded irregularly shaped grains of magnetite and pyrite. Porphyroblasts of biotite .1 to 1 mm long are numerous within the matrix of most wackes. The clastic quartz grains and the finer grained quartz grains in the matrix indicate that the quartz grains had a bimodal size distribution during deposition.

The meta-arenites are massive metasandstones composed of 40 to 80 percent quartz and minor plagioclase clasts of nearly equal size. The grain size of the arenites ranges from 0.5 to 2 mm. The clastic quartz and plagioclase grains are angular to rounded and are supported by a matrix consisting of 0.01 to 0.5 mm sized lepidoblastic biotite and muscovite and interstitial quartz and albite.

The metasiltstones and mudstones contain less quartz and plagioclase clasts than the metawackes and arenites. The clasts are 0.1 to 0.5 mm in size and are more sparely distributed in the matrix. Where the clasts make up less than 10 percent of the

rock, the rock is mainly comprised of lepidoblastic micas with interstitial quartz and albite with minor magnetite and pyrite grains. Some mudstones contain rectangular, 1 to 3 mm sized, porphyroblastic pseudomorphs after chloritoid, or possibly cordierite, replaced by fibrous sericite, clinozoesite and albite (Photo 4). Some of the porphyroblasts are rotated and form augen.

Interflow Metasedimentary Rocks

The metasedimentary interflow rocks are thin metasedimentary units 0.5 to 3 m thick intercalated with many of the thicker units of tholeiitic metabasalt in the Central and Northern Domains. Many of these units have constant thicknesses over distances of several kilometers. Others are lensoidal and only locally traceable. Some of the interflow metasedimentary rocks south of Horseshoe Lake appear to represent thin eastward continuations of the above described thicker, more diverse metasedimentary units located in the northwest part of the Horseshoe Lake Belt north of Kecheokagan Lake. Three analyses of these rocks are shown in Table 3, p. .

The interflow metasedimentary rocks are mainly dark green to grey, 0.1 to 2 mm grained, micaceous, quartz-bearing rocks. Quartz which ranges from 10 to 60 percent of the various interflow units, can occur as descrete angular to rounded, 0.1 to 1 mm sized, detrital grains in a lepidoblastic matrix of biotite, chlorite and actinolite with interstial quartz and albite or as

larger granoblastic quartz grains interlocked with grains of biotite, actinolite, magnetite and albite.

Chert, iron formation or mudstone rarely occur as interflow metasediments although some weakly magnetic, magnetite-bearing wackes do occur. Some interflow iron formation and chert occurs in a tholeiitic metabasalt remanent in the granitoid gneisses located on the Pipestone River, 5 km southwest of Kecheokagan Lake.

Pebbly Wackes

The pebbly wackes, forming beds 0.5 to 3 m thick are noteworthy because they contain numerous 0.5 to 3 cm clasts of chert, vein quartz, and sulphide and in places, contain anomalous gold values of >20 ppb. Many form rusty gossans as a result of sulphide weathering. The pebbly wackes form subunits within the thicker metasedimentary units that extend across the southwest part of Horseshoe Lake (see map P.3219, back pocket). Within the metasedimentary units they occur at the base of sedimentary cycles that grade upward into metawacke, -siltstone and chert, that in places contain laminae of pyrite 1 to 2 mm thick.

The matrix of the pebbly wackes is a wacke like those described above, except that 1 to 2 mm sized grains of clastic pyrite and pyrrhotite are more abundant in the pebbly wacke than in the pebble-free wackes.

Quartz Arenite

Quartz-arenite that contains >80 percent detrital quartz, occurs as white, homogeneous, thin subunits in the metasedimentary units of the Central and Northern Domains. Some retain a 0.5 to 1 mm granular texture; others appear as massive quartzite. The best exposures of this rock type occurs 4 km north of Kecheokagan Lake in the northwest part of the Horseshoe Lake greenstone belt. Here beds .5 to 10 m thick alternate with cherty siltstone and mudstone layers up to 1 m thick. In places the quartz-arenite is stained by hematite from the weathering of minor pyrite in the rock.

In this section quartz arenite show angular to rounded strained clastic quartz grains 0.1 to 1 mm in size impinge on one another and lepidoblastic muscovite and granoblastic quartz and albite fill the interstices of the clastic quartz grains.

Magnetite-bearing Wacke and Arenite

A metawacke-arenite unit, up to 400 m thick, rich in magnetite occurs northeast and east of Kecheokagan Lake. It is homogeneous, light grey to black in colour, 1 to 2 mm grained, and magnetic. Bedding planes are difficult to detect on most outcrops and, in places the rocks become difficult to distinguish from iron-rich, magnetic tholeiitic basalt. A distinguishing feature is their granular texture. The rocks consist of granoblastic to lepidoblastic hornblende, quartz and magnetite plus minor plagioclase and biotite and accessory zircon and apatite (Photo 5). Four chemical analyses of these rocks are in

Table 3. They show this rock-type to be rich in quartz, magnetite, sodium, zirconium and yttrium.

The magnetite-rich metasedimentary rocks cause a high magnetic expression on aeromagnetic map 916G (ODM-GSC, 1960). This magnetic anomaly extends west over an area where the rocks were mapped as Fe-rich tholeiitic basalts 1.6 km north of Kecheokagan Lake. It is possible that this Fe-rich unit of tholeiitic basalt contains interbeds of magnetite-bearing metasediments not recognized during the mapping or that it represents the source of the magnetite for the metasedimentary rocks.

Fuchsite bearing Metasedimentary Rocks

Fuchsite-bearing siltstone (Photo 6) and mudstone occurs 2.4 km north of Kecheokagan Lake and 2.5 km west-southwest of Horseshoe Lake. These rocks consist of 20 to 40 percent 0.1 to 0.5 mm sized, angular to surrounded clastic quartz set in a micaceous matrix of fuchsite, muscovite, albite, and quartz with accessory magnetite.

These rocks are also present as 1 to 10 cm thick green layers and as 1 to 5 cm long stretched rip-up clasts in the Upper Conglomerate.

Chemical Metasedimentary Rocks

In the Central and Northern Domains, the chemical metasedimentary rocks are chert, iron formation and limestone. Chert units occur within the large units that contain arenite and

mudstone in the Northern Domain and toward the top of the succession in the Central Domain. They are 0.5 to 10 m thick, and comprised of light green to grey, vitreous, translucent finely laminated to massive rocks composed of granoblastic quartz grains 0.01 to 0.1 mm in size. The laminae are comprised of muscovite and minor magnetite. Mylonitized chert is comprised of strongly strained subparallel, needle to lens-shaped interlocking quartz grains. Elsewhere, chert forms thin laminae toward the top of some thin siltstone and mudstone beds and occurs as black to grey layers in iron-formation.

The occurrences of iron formation are mainly within the eastern part of the Lower Conglomerate. Here, the 1 to 10 m thick units consist of fine-grained, alternating layers of magnetite, chert, and actinolite 0.5 to 2 cm thick. Sulphide-rich portions of the unit cause gossans. Elsewhere, iron formation occurs as 1 cm thick cherty layers within siltstones and mudstones.

Limestone occurs only on the south shore of Horseshoe Lake where it forms a 1 m thick bed interlayered with cherty siltstone and wacke (See analysis B13, Table 3) . The bed can be traced 0.5 km along shore before it disappears under water. The rock consists of 0.1 to 0.5 mm sized granoblastic calcite and minor magnetite, sericite, and pyrite. It is underlain by strongly carbonatized and chloritized, blue quartz-bearing, massive, Fe-rich tholeiitic basalt.

Metasedimentary Rocks of the Calc-alkalic Domain

The metasedimentary rocks of the Calc-alkalic Domain are comprised of banded iron formation associated with zones of sulphide-rich chert and minor amounts of calcareous mudstone and graphitic mudstone. Iron-formation forms 1 to 10 m wide continuous units within the calc-alkaline tuffs. One unit occurs on the islands at the east end of the southeast arm of Horseshoe Lake and another, 2.6 km long and 1 to 3 m wide, occurs farther west across the narrows of Horseshoe Lake toward the north side of the Calc-alkalic Domain. Several other units have been intersected by diamond drilling east of Horseshoe Lake. Some sulphide facies iron formation and schistose graphitic siltstone are exposed with this band of Iron formation. At the south east end of Horseshoe Lake, the iron formation produces a strong magnetic anomaly on aeromagnetic Map 916G (GSC, 1960). Similar magnetic anomalies occur farther east, north of Wapamisk Creek and Lake to suggest that the calc-alkalic metavolcanics interlayered with iron formation extend east under the Agutua Morain (Prest, 1966).

Narrow sulphide-rich chert units also occur along the northwest shore of the southeast arm of Horseshoe Lake. Three separate zones were observed having a maximum width of 1 m. They contain up to 25 percent densely disseminated pyrite and form gossans. The pyrite is densely disseminated in bands within the chert. The cherts may represent cherty tuffs or they may represent silicified shear zones as some appear to transect the metavolcanic rocks as a low angle to strike. Thin section examinations were not made on these rocks. Similar pyritic

cherts are also present near the iron formation toward the east end of southeast Horseshoe Lake.

METAVOLCANIC ROCKS

Introduction

The metavolcanic rocks of the Horseshoe Lake Greenstone Belt consist of a tholeiitic volcanic suite located mainly in the Central and Northern Domains and a calc-alkalic volcanic suite which occupies the Calc-alkalic Domain. A few tuffaceous felsic calc-alkalic metavolcanic rocks are also present in the Central Domain. Komatiitic metavolcanic rocks; not uncommon in the supracrustal successions of the Sachigo Subprovince (Breaks et al. 1985 and Thurston et al. 1987) were not observed in the Horseshoe Lake Greenstone Belt. However, fuchsite-bearing metasedimentary rocks are present in the area and suggest that chromium rich source rocks, possibly peridotitic komatiites, may have been part of the volcanism in the Horseshoe Lake Greenstone Belt.

Jensen's (1976) classification was applied in the field to make a preliminary identification of the metavolcanics rocks based on mineralogy, colour, hardness, texture, magnetic properties and flow morphology (Jensen and Langford, 1985). Field identification of the rock types becomes less certain in areas where extensive alteration combined with deformation and metamorphism has affected the rocks.

In the mafic portion of tholeiitic volcanic suite, Mg-rich tholeiitic basalt, Fe-rich tholeiitic basalt and tholeiitic

andesite form a continuum of rocks. In most places, Mg-rich tholeiitic basalt, a green to dark green gabbroic textured, nonmagnetic rock can be readily distinguished from Fe-rich tholeiitic basalt and tholeiitic andesite which are dark green to black, diabasic textured, magnetic rocks. A few flows have properties intermediate between the two end groups of tholeiitic volcanic rocks and without chemical analyses cannot be accurately classified. These flows represent the transition from Mg-rich tholeiitic volcanism to Fe-rich tholeiitic volcanism. These volcanic cycles resulted through mineral fractionation and in the absence of pillows, the rock sequence provides a criterion for younging directions. Where these intermediate flows occur, it is difficult to accurately position the contact between a unit of Mg-rich tholeiitic basalt and a unit of Fe-rich tholeiitic basalt. Most units of Fe-rich tholeiitic basalt have anomalously high magnetic expressions on the aeromagnetic maps which are a useful tool for mapping the volcanic stratigraphy.

Similarly, in the mafic portions of the calc-alkalic volcanic suite, high-Al tholeiitic basalt, calc-alkalic basalt and calc-alkalic andesite have indistinguishable rock properties and cannot be distinguished in the field without chemical analyses. In the Horseshoe Lake Belt these rocks form a continuum and, as in the Abitibi Greenstone Belt, are interlayered with another (Jensen and Langford, 1985). In this report, these rocks have been considered as one group of rocks and are distinguished from the more felsic calc-alkalic dacite and rhyolite end members.

No tholeiitic subvolcanic rocks related to the tholeiitic volcanism were identified. Thick conformable sill-like bodies were interpreted to be flows. The mafic dikes which cut the tholeiitic metavolcanic rocks have non-tholeiitic chemical and mineralogical properties and will be discussed below.

The calc-alkalic metavolcanic rocks are intruded by subvolcanic feldspar and quartz-feldspar-phyric dikes and gabbroic stocks. These rocks will be discussed with the calc-alkalic metavolcanic rocks and with the internal intrusive rocks of the Horseshoe Greenstone Belt.

Tholeiitic Metavolcanic Rocks
(Units 2, 3 and 4)
Distribution

In the Central and Northern Domains, the tholeiitic metavolcanic rocks are mainly Mg-rich and Fe-rich tholeiitic basalt. Minor tholeiitic andesite occurs associated with the Fe-rich tholeiitic basalt and minor tholeiitic dacite occurs near the top of the volcano-sedimentary succession of the Central Domain. The Mg-rich and Fe-rich tholeiitic basalts form map units from 25 to 1000 m thick or occur as thin intersedimentary flows. Most thick units, especially those within units of metasedimentary rock greater than 100 m thick, are comprised of numerous flows that range from 1 to 100 m thick. Flow contacts within units are difficult to recognize except where flow selvages and interflow sedimentary rocks are present.

In the middle portions of the metavolcano-metasedimentary succession of the Central Domain, several map-units of Mg-rich and Fe-rich tholeiitic metabasalt can be traced kilometer distances along strike. Many of the units appear to thicken eastward at the expense of the metasedimentary rocks. South east of Horseshoe Lake and south of Wapamisk Lake, metasediments are lacking with in the tholeiitic metavolcanics. An eastward increase in the proportion of metavolcanic rock to metasedimentary rock can also be observed in the Northern Domain.

The tholeiitic volcanic rocks have cyclic iron-enrichment trends. A complete cycle consists of a coarse-grained pyroxene-phyric rock at the base that grades up into medium-grained equigranular gabbroic-texture rocks. The central part of the cycle, the rocks become plagioclase-pyrite, and are overlain by diabasic to granophyric textured rocks that show iron enrichment i.e. they are magnetic. Below the plagioclase-phyric zone, the rocks are chemically equivalent in composition to Mg-rich tholeiitic basalt and above, they are equivalent to Fe-rich tholeiitic basalt to tholeiitic andesite. In the stratigraphically highest tholeiitic cycles, the Fe-rich tholeiitic basalts contain blue quartz and in places, minor tholeiitic dacite occurs in association with these Fe rich units.

Chemistry

Whole-rock analyses were completed on 14 hand specimens representing the metavolcanic rocks of the Central Domain (Table 4). In addition, 3 analyses, described as gabbro by Sage and

Breaks (1982) are included in Table 4. The sample locations are indicated on the geological map (in back pocket).

On the Jensen Cation Plot (Figure 4), the rock analyses project in the Mg-rich and Fe-rich tholeiitic basalt fields and tholeiitic andesite field except for sample T6. Sample T6 which projects within the calc-alkalic basalt field because of its high aluminum content, has above average content of primary plagioclase in thin section, but otherwise, is similar in mineralogy and texture to the samples with analyses that project near the boundary between the Mg-rich and Fe-rich tholeiitic basalt fields.

In the mafic tholeiitic metavolcanic rocks, magnesium varies from 10 percent to 2 percent as total iron increases from 11 percent to 21 percent, and titanium from 0.50 to 1.80 percent. This strong iron enrichment trend occurs as silica ranges from 46.5 to approximately 51.0 percent and aluminum from 12.0 to 17.0 percent. The highest aluminum percentages tends to occur in rocks which project close to the boundary between Mg-rich and Fe-rich tholeiitic basalt on Figure 4. This suggests that the crystallization of plagioclase as well as pyroxene was responsible for the observed iron-enrichment in the tholeiitic basalts. Sodium shows a general increase from 1.3 to 4.0 percent as calcium decreases from 11.5 to 4.2 percent with iron-enrichment. Potassium remains below 0.4 percent.

Among the trace elements, chrome and nickel contents shows a general decrease with the decrease in magnesium; zirconium shows an increase with iron-enrichment.

The CIPW normative mineral calculations indicate samples T2, T3, T8, T16, AZ and BC (Table 4) are weakly olivine normative. The remaining samples are weakly quartz normative. The principal normative minerals are plagioclase (An>50) and pyroxene with magnetite becoming an important constituent in the iron-rich tholeiitic basalts.

Mg-rich Tholeiitic Basalt
(Unit 2)

Mg-rich tholeiitic basalt is the most abundant rock-type in the Horseshoe Lake Belt. It forms coarse-to fine-grained flows with minor amounts of pillowed flows, pillow breccia and hyaloclastite. These metavolcanic rocks comprise units that can be traced along strike for several kilometres. Some of the coarse-grained rock units may be subvolcanic sills.

The most common variety of Mg-rich tholeiitic basalt forms a 1 to 3 mm grained, dark green, gabbroic textured rocks in which tabular- to anhedral shaped hornblende pseudomorphs after clinopyroxene ophitically encloses subhedral laths of plagioclase 1 to 2 mm in length. The hornblende pseudomorphs form 60 to 80 percent of the rock and the plagioclase, 20 to 40 percent. The plagioclase laths are albite in composition indicative of upper greenschist metamorphism and contain numerous needle-shaped actinolite grains 0.01 to 0.1 mm in length. In areas of lower amphibolite grade metamorphism, the hornblende pseudomorphs form 2 to 4 mm sized areas comprised of interlocked subhedral, 0.1 to

0.5 mm granoblastic hornblende grains partly separated by areas of interstitial granoblastic plagioclase, quartz, and hornblende.

In many places, the gabbroic textured Mg-rich tholeiitic basalts grade downward within flows into coarse, knobby surfaced, dark green to black clinopyroxene-phyric metabasalts (Photo 7). The pyroxene phenocrysts which form from 50 to 95 percent of the rocks, are tabular, 0.5 to 3 cm sized crystals replaced by optically continuous hornblende (Photo 8).

In many places, the gabbroic textured Mg-rich tholeiitic basalts grade downward within flows into or are interlayered with coarse, knobby surfaced, dark green to black clinopyroxene-phyric metabasalts (Photo 7). These clinopyroxene-phyric metabasalts have a range of textures and mineral compositions that vary with the size and percentage of clinopyroxene phenocrysts. The clinopyroxene phenocrysts form from 50 to 90 percent of the rock, are tabular, and are 0.5 to 3 cm sized crystals replaced by optically continuous hornblende under middle to upper greenschist metamorphic conditions (Photo 8). In the metabasalts where the pyroxene phenocrysts are less than 1 cm in size and form less than 70 percent of the rock, the phenocrysts are ophitic and are surrounded by a 1 to 3 mm grained matrix of ophitic hornblende pseudomorphic after pyroxene and plagioclase of albite composition. This matrix is similar in composition to the gabbroic texture Mg-rich tholeiitic basalts. As the pyroxene phenocrysts increase in size from 1 cm to 3 cm and percentage from 70 to 90 percent in the metabasalt, the phenocrysts become

less ophitic and tightly packed and the matrix forms only a minor part of the rock.

Where the pyroxene-phyric metabasalts grade from upper greenschist to lower amphibolite metamorphism the hornblende phenocrysts pseudomorphic after pyroxene become transformed into aggregates of 0.1 to 0.5 mm granoblastic hornblende outlined by granoblastic quartz and plagioclase that contain numerous needles of hornblende and small grains of magnetite. The proportion and size of the aggregates of granoblastic hornblende appears to represent the approximate size and percentage of the pyroxene phenocrysts in the primary basalt.

The coarse pyroxene-phyric flows range from 5 to 100 m thick and in many places, form a continuous vertical series of flows. These flows can be separated from one another by thin zones of interflow metasedimentary rock and by flows of thin finer grained Mg-rich tholeiitic metabasalt. Many of the flows are comprised of greater than 80 percent tightly packed 1 to 3 cm sized pyroxene crystals altered to hornblende (Photo 9), and contain only minor amounts of finer grained, non-porphyritic rock. In places, some thick flows do show poorly developed cumulate layering and the gradation upward into finer-grained non porphyritic rock both within single flows and in series of flows interlayered with thin interflow metasedimentary units. The author believes that the pyroxene phenocrysts were formed at depth and rafted to surface where they quickly settled in the flows. The flows either carried very high concentrations of pyroxene phenocrysts for several kilometers or much of the

unconsolidated lava drained during the settling of the phenocrysts and form finer-grained flows elsewhere.

In places, the bedding of the thick metasedimentary rocks is at a shallow unconformable angle to their contact with the underlying fine-grained top of some coarse pyroxene-phyric flows (Photo 10). Either the pyroxene-phyric rocks are sills emplaced at a shallow angle to the metasedimentary rocks or synvolcanic tilting had occurred after the extrusion of the flows and before the deposition of the metasedimentary rocks. Contact metamorphic aureoles are absent and sheared contacts are rare between the two metavolcanic and metasedimentary rocks. Regardless whether the pyroxene-phyric rocks are sills or flows, it is difficult to explain both their emplacement and high phenocryst concentration without the immediate subsequent removal of considerable magma.

Some Mg-rich tholeiitic basalt flows contain scattered plagioclase phenocrysts 0.5 to 1 cm in size. No thin sections were made of these rocks but as can be seen on handspecimens they consist of a mafic greenschist mineral assemblage. In places, they are weakly magnetic and are classified as Fe-rich tholeiitic basalts.

The fine-grained Mg-rich tholeiitic basalts are dark grey to green rocks found within pillowed flows and along the base and tops of the coarser grained flows. They consist of fibrous actinolite and chlorite intergrown with hornblende pseudomorphs after pyroxene, with interstitial albite and some quartz. Where amygdules are found, they are filled with interlocking quartz grains that contain actinolite needles.

Most of the Mg-rich tholeiitic metabasalts show retrograde metamorphism through the development of actinolite, tremolite and chlorite along the margins of the hornblende grains pseudomorphic after pyroxene. In zones of shearing, the hornblende pseudomorphs become augen enclosed by fibrous actinolite and chlorite with interstitial albite and quartz and where metasomatized, interstitial carbonate. Many of the hornblende pseudomorphs after pyroxene are fractured and have been reduced in size and rounded during deformation.

The Mg-rich tholeiitic metabasalts of the Horseshoe Lake Greenstone Belt have identical chemical composition to those of the Abitibi Greenstone Belt. The textures and mineralogy of the gabbroic to fine grained rocks are similar too (Jensen and Langford, 1985). However, pyroxene-phyric Mg-rich tholeiitic basalt, to the author's knowledge have not been observed or reported in the Abitibi Greenstone Belt which suggests that tholeiitic volcanism occurred in both greenstone belts under distinctive crustal settings.

Fe-rich Tholeiitic Basalt and Andesite (Unit 3)

The Fe-rich tholeiitic basalts and andesites differ from the Mg-rich tholeiitic basalts by their darker colour, diabasic texture and magnetism. They form less than 40 percent of the tholeiitic metavolcanic rocks. Their magnetic property makes them useful for mapping purposes. Although these rocks have undergone upper greenschist to lower amphibolite metamorphism,

and regional deformation, their primary textures are preserved. Only along shear zones particularly where metasomatism has occurred, are the primary textures destroyed. In the Northern and Southern Domains, most of the Fe-rich tholeiitic basalts are massive flows composed of 1 to 4 mm grained, dark green to black, weakly to strongly magnetic, diabase textured rock. They consist of 40 to 60 percent subophitic 2 to 4 mm long hornblende laths pseudomorphic after pyroxene. The hornblende laths enclose 1 to 3 mm long laths of plagioclase of andesine composition. Plagioclase makes up 30 to 50 percent of the rock. The rock contains 5 to 15 percent magnetite which is 0.1 to 2 mm sized, forms equant grains and tends to occur interstitial to the hornblende pseudomorphs along with plagioclase and, in places, strained quartz. Numerous micron-size tremolite and chlorite needle-shaped grains are contained in the plagioclase and quartz and in most rocks, the hornblende pseudomorphs are partly altered to fibrous tremolite suggesting that the rocks were subjected to retrograde metamorphism.

Some flows, that are thicker than 30 m, contain granophyric basaltic to andesitic phases composed of 2 to 11 cm long black, hornblende laths pseudomorphic after pyroxene and ophitically enclosing white plagioclase laths. Patches of magnetite, quartz and plagioclase occur interstitial to the hornblende laths. These granophyre-bearing flows are best observed 2 km south of Horseshoe Lake and 7 km east of Kecheokagan Lake.

Some Fe-rich tholeiitic basalts contain opalescent 1 to 4 mm sized, subround, blue quartz grains in a dark green to black, 1

to 3 mm matrix. Samples T10, T11 and T12 (Table 4) are analyses, representative of these rocks. The quartz grains are large single, strained, crystals whose boundaries are interstially interlocked with plagioclase, magnetite and hornblende pseudomorphs after pyroxene.

The fine-grained massive and pillowed Fe-rich tholeiitic basalts and andesites, consist of 0.01 to 0.51 mm long needles of fibrous tremolite and chlorite with interstitial albite and quartz. Finely disseminated magnetite occurs throughout the rock.

Along zones of shearing the Fe-rich tholeiitic basalts become chlorite-rich schists. Where quartz is present, it is stained and rounded to form augen. This can be observed in the blue quartz-bearing Fe-rich tholeiitic basalt unit along the south shore of Horseshoe Lake. In many places, this unit is carbonatized and has calcite interstitial to the chlorite, tremolite, and magnetite which is reflected in the analyses of T5, T7, T10 and T11 (Table 4).

Tholeiitic Dacite and Rhyolite
(Unit 4)

Tholeiitic dacite and rhyolite form only a minor portion of the tholeiitic metavolcanic rocks. The largest exposure of these rocks occur on an island in the southeast arm of Horseshoe Lake. Here they are associated with Fe-rich tholeiitic metabasalt and form 10 m thick units. They are cherty black to light green and yellow coloured, poorly bedded tuffs which are weakly magnetic in

places. They consist of 75 to 80 percent, 0.01 to 0.03 mm size granoblastic quartz and albite interstitial to actinolite laths and equant magnetite grains that are of similar size. They lack the mica of metasedimentary rocks and the sericite and carbonate of calc-alkalic dacite and rhyolite tuffs.

Calc-Alkalic Metavolcanic Rocks
(Units 5 and 6)

Distribution

The calc-alkalic metavolcanic rocks occupy the Calc-alkalic Domain located on the north side of the Horseshoe Lake Belt (Figure 3). They occur in a fault-bounded wedge of rocks about 4 km west of Horseshoe Lake and continue east past Wapamisk Lake. Their best exposures occur along the northshore of southwest Horseshoe Lake where they range in composition from calc-alkalic basalt to rhyolite.

A few calc-alkalic felsic tuffs occur about 2 km north of Kecheokagan Lake in the centre part of the Central Domain where they are interlayered with the metasedimentary and tholeiitic metavolcanic rocks. Clasts of massive and pumiceous felsic calc-alkalic metavolcanic rocks are contained in the metaconglomerates north of Kecheokagan Lake.

Chemistry

Only 5 hand specimens of extrusive rock from the calc-alkalic volcanic suite of the calc-alkalic Domain were analyzed (Table 5). Included in Table 4 are two analyses of quartz-

feldspar porphyry dikes and one analyses from a gabbroic stock considered to be subvolcanic and belong to the calc-alkalic metavolcanic suite.

On the Jensen Cation Plot (Figure 7), the extrusive rocks project from the tholeiitic field into the calc alkalic field to display an aluminum enrichment trend in contrast to an iron-enrichment shown on a similar diagram for the tholeiitic metavolcanic rocks (Figure 6). Sample C1 which plots in the Mg-rich tholeiitic basalt field has a total iron oxide content of less than 10 percent unlike those analyses of tholeiitic rocks listed in Table 4. The gabbro (I1, Table 5) sample occurs within the basaltic komatiite field but unlike komatiites, this rock also contain less than 10 percent total iron (see Howe et al., 1987). This sample has a chemical composition similar to boninite found in calc-alkalic island-arc complexes (Sun and Nesbitt, 1978).

The main chemical feature of the calc-alkalic suite is its low iron content of less than 10 percent compared the higher iron content of the tholeiitic volcanic with similar silica contents. The spectrum of calc-alkalic volcanic and related subvolcanic rocks observed in the Calc-alkalic Domain is similar to that found in Blake River Group in the Abitibi Greenstone Belt (Jensen and Langford, 1985).

Calc-Alkalic Basalt and Andesite
(Unit 5)

The calc-alkalic basalts and andesites as well as their associated Mg-rich tholeiitic basalts are mainly green to grey, fine- to medium-grained rocks that occur as massive and pillowed flows and as fragmental and tuffaceous rocks. The massive flows are 5 to 50 m thick and occur in successions up to 200 m thick that can be traced for km distances along strike. These successions alternate with successions of pillowed flows of comparable thicknesses. The successions of pillowed flows lava are from 2 m to 100 m thick and in the thicker successions, can contain interlayered massive flows as well as layers of pillow breccia, tuff-breccia and tuff. Where undeformed, the pillows range from 10 to 100 cm in diameter, are tightly packed, and are sharply outlined by their cooling selvages (Photo 11). Near the margins of the Calc-alkalic Domain, the pillows are stretched and flattened parallel to the strike of the rock units 2 to 10 times their original diameter.

The tuffaceous rocks of basalt and andesite composition are massive to well-bedded, grey to light grey, chloritic rocks. They are rocks with 1 to 2 cm sized pyroclasts down to rocks of only ash-sized material. Many of the 2 to 20 cm thick beds of 1 to 3 mm grained material are composed of crystal and lapilli fragments set in an ash matrix which shows graded bedding (Photo 12). In places they have interlayered units of tuffaceous calc-alkalic dacite and rhyolite as well as layers of iron-formation, chert, and graphitic mudstone with and without associated pyrite and pyrrhotite.

In the Calc-alkalic Domain, the metavolcanic rocks have undergone lower to middle greenschist facies metamorphism. Albite, epidote, chlorite, quartz, actinolite, leucoxene and carbonate are the main minerals within the mafic calc-alkalic rocks. The 1 to 3 mm grained calc-alkalic basalts and Mg-rich tholeiitic basalts within the massive flows consist of 45 to 65 percent equant clinopyroxene partly to completely altered to chlorite, epidote and actinolite. The 1 to 2 mm long plagioclase laths are saussuritized to albite, clinozoisite, and chlorite and occur with interstital quartz, carbonate and chlorite to form the groundmass surrounding the altered pyroxene. Finely disseminated secondary magnetite and leucoxene occur throughout the rock, particularly marginal to the pyroxene grains. The finer-grained mafic calc-alkalic rocks consist of subparallel fibrous chlorite and actinolite and contain interstitial albite, quartz and carbonate and micron sized grains of epidote, leucoxene and magnetite. Augen-shaped amygdules, 0.5 to 1.5 mm long, are filled with numerous interlocking, equant, quartz grains. Rocks of andesite composition have 1 to 2 mm long plagioclase phenocrysts set in a groundmass with greater amounts of quartz and albite than the basalts.

Tuffs of basalt and andesite composition form 15 to 20 percent of the calc-alkalic rocks. On subhorizontal outcrop surfaces, the tuffs appear well preserved (Photo 12) but in subvertical planar directions, they are strongly deformed and show prominent, steeply plunging mineral lineations. In the tuffs, the original ash has been altered to mm wide lenticles of

granoblastic calcite and subordinate quartz enclosed in a matrix of fibrous chlorite, of epidote, albite, quartz and leucoxene. In places, the rock contains finely disseminated pyrite and magnetite.

In the crystal tuffs, the crystal fragments are largely chipped andesine and oligoclase and subordinate quartz. Many of the plagioclase grains have primary compositions and retain twinning and show only partial alteration. Some have undergone rotation and in the pressure shadows of these crystal clasts, carbonate and quartz formed during deformation. The plagioclase crystal fragments are from 0.1 to 4 mm long and make up from under 10% to over 50% of the rock. At their base, many beds contain more than 50 percent crystal fragments. Upward in the beds the crystal fragments decrease in size and abundance.

The basalt and andesite tuffs and crystal tuffs were probably distally derived and deposited in a subaqueous environment. They are interlayered both, with pillowed flows and with iron formation. Coarse pyroclastic rocks with centimeter size pyroclasts are rare in the calc-alkalic succession except for a few lapilli tuffs. The lapilli consist of chlorite, epidote, albite and quartz.

Calc-alkalic Dacite and Rhyolite
(Unit 6)

In the Calc-alkalic Domain, the calc-alkalic dacites and rhyolites represent less than 5 percent of the observed calc-alkalic metavolcanic rocks. They consist of light grey to white,

siliceous, massive to bedded, 1 to 10 m thick units and occur interlayered with the more mafic tuffs. They are crystal tuffs that contain subhedral to rounded, 0.1 to 3 mm sized plagioclase and quartz crystals in a quartzo-feldspathic matrix that contains micron sized sericite, chlorite and epidote (Photo 13). The plagioclase is oligoclase to albite in composition and the quartz is strongly strained.

The felsic calc-alkalic tuffs are best exposed along shores at the east end of Horseshoe Lake. Where bedded, the beds are 1 to 10 cm thick and show graded bedding by being more siliceous toward their top.

In the Central Domain, the calc-alkalic dacite and rhyolites located north of Kecheokagan Lake are similar in appearance, composition and texture to those of the Calc-alkalic Domain. They are interlayered with metasedimentary rocks between thick units of tholeiitic metavolcanic rock. The matrix which encloses the plagioclase and quartz fragments consists of .01 to 0.1 mm sized granoblastic quartz and plagioclase interstitial to grains of muscovite, biotite and tremolite.

Neither the Central Domain or the Calc-alkalic Domain contain massive to coarse fragmental felsic flows or pyroclastic rocks which would suggest that the felsic crystal tuffs were locally derived; all appear to be distally derived. Clasts of massive and pumiceous felsic metavolcanic rock occur only in the lower conglomerates of the Central Domain. This indicates massive flows and coarse pyroclastic rocks were probably present somewhat distant from the present study area. It is uncertain

whether the felsic calc-alkalic rocks in the Central Domain and the Calc-alkalic Domain are from a single source or are of separate ages and sources.

Subvolcanic Calc-alkalic Rocks

(Units 7 and 9b)

Distribution

The subvolcanic calc-alkalic rocks are part of a group of intrusive rock found internal to the metavolcano-metasedimentary succession of the Horseshoe Lake Greenstone Belt. Because of the close spatial association with the calc-alkalic metavolcanic rocks and their composition, they are discussed with the calc-alkalic extrusive rocks. The intrusive rocks may have acted as feeders for some of the calc-alkalic extrusive rocks.

The mafic intrusive rocks consist of gabbro and anorthositic gabbro stocks which cut the calc-alkalic metavolcanic rocks 2 km west of Horseshoe Lake. On the map (in back pocket), the stocks show as 1.5 km long elongate composite intrusive bodies.

The felsic intrusive rocks are east-trending dikes of quartz-feldspar and feldspar porphyry located on Horseshoe Lake in the Calc-alkalic Domain. The feldspar phenocrysts are albite to andesine in composition in contrast to the phenocrysts of potassium feldspar in dikes of map unit 15 (in back pocket).

Mafic Intrusive Rocks

(Unit 7)

The mafic intrusive rocks west of Horseshoe Lake are mainly massive 2 to 5 mm grained gabbro and anorthositic gabbro. Depending on their hornblende and actinolite content, they range in colour from dark green to light grey. Sample I1, Table 4, is a representative of these rocks. Chloritic hornblende and actinolite have replaced clinopyroxene and tend to form clusters of 3 or more, equant, 1 to 4 mm sized interlocking grains. At the margins of the clusters, the pseudomorphs after clinopyroxene ophitically enclose saussurititized plagioclase. The saussurite consists of finer-grained albite, chlorite, quartz, epidote, actinolite and leucoxene. Secondary, 1 to 10 micron sized magnetite grains occur in the hornblende pseudomorphs.

In the most mafic gabbros, the clusters of mafic minerals pseudomorphic after clinopyroxene impinge on one another and plagioclase occurs interstitially. With increasing plagioclase content and the formation of anorthositic gabbro, these clusters become separated and form less than 30 percent of the rock.

Plagioclase and Quartz-Plagioclase-Porphyry Dikes (Unit 9b)

The plagioclase and quartz-plagioclase porphyry dikes intrude the calc-alkalic metavolcanic rocks at a low angle to the strike of the metavolcanic rocks. The dikes are 5 to 20 m wide and extend for distances of less than 1 km. The porphyritic rocks are massive to gneissic, light grey rocks in which white plagioclase and glassy quartz can be observed in a hard, fine grained, grey matrix. The plagioclase is andesine to oligoclase

in composition and forms 1 to 6 mm subsequent euhedral crystals which are partly altered to chlorite, white mica, and albite (Photo 14). The quartz grains are subrounded bipyramids and have deep resorption embayments filled with matrix material. The 0.01 to 0.5 mm grained matrix consists mainly of interlocking quartz, albite, calcite interstitial to subordinate chlorite, actinolite and mica. Clusters of numerous biotite grains form 1 to 2 mm sized patches which probably represent the replaced hornblende. Where the porphyries are gneissic, the phenocrysts form augen and granoblastic biotite occurs as lenticles. In these rocks, the plagioclase is strongly saussuritized and the quartz grains are strongly strained.

INTRUSIVE ROCKS

Introduction

The intrusive rocks comprise dikes and stocks which internally cut the supracrustal rocks of the Horseshoe Lake Greenstone Belt and rocks of the gneissic-granitoid terrain which occur external to the belt. The internal intrusive rocks, consist of subvolcanic gabbros and felsic porphyry dikes of the Calc-alkalic Domain described above and are mafic dikes, lamprophyre dikes, perthite and quartz-perthite-phyric dikes, and late diabase dikes. A small trondhjemite stock and a granodiorite stock approximately 0.8 km in diameter also cut the supracrustal rocks.

The external intrusive rocks are gneissic and melanocratic to leucocratic. The author believes that these rocks were

derived by anatexis with the addition of felsic magmas from metasedimentary, tholeiitic and calc-alkalic metavolcanic rocks. The gneisses contain numerous xenoliths of the supracrustal rocks and are cut by dikes and sills of granitoid mobilizate. Batholiths of equigranular to pegmatitic monzogranite and syenogranite intrude the gneissic rocks in the part of the map area.

The age relationship between the internal and external intrusive rocks is not possible to determine for all rock types, particularly for the trondhjemite and granodiorite stocks. The trondhjemite stock may be a felsic subvolcanic calc-alkalic body which intruded the tholeiitic Central Domain. The granodiorite stock at the east end of Kecheokagan Lake intrudes both the gneissic rocks and the supracrustal rocks. Because it cuts the gneisses and because its high primary K-feldspar content, it is placed with similar late granitoid rocks (Map, back pocket). However, it has undergone a period of deformation that is observed in the adjacent gneisses but not in the late granitoids.

The perthite- and quartz-perthite-phyric dikes and lamprophyre dikes cut both the supracrustal rocks and the granitoid gneisses to the south and because of their mineralogy are considered to be related to the late K-rich granitoids batholith south of the map area.

The mafic dikes have a distinctive chemical composition, mineralogy, and distribution which suggests they are unrelated to any other group of rocks observed in the map area. Some cut the supracrustal rocks and others cut the granitoid gneisses which

suggests, if they are all related, that a small late mafic magmatic event occurred after the granitoid gneisses were formed.

The diabase dikes, because of their well preserved primary textures and mineralogy are considered to post-date all other rock types.

The granitoid rocks were examined by feldspar staining and by studying thin sections.

The classification of the various granitoid rocks is based on Streckeisen (1976). Streckeisen's granite field in which K-rich alkali feldspar forms 35 to 90 percent of the total feldspar has been divided into fields of monzogranite and a syenogranite. In monzogranite, the alkali feldspar forms 35 to 65 percent and in syenogranite, 65 to 90 percent of the total feldspar. Terminology used to describe textures and structures within the migmatitic rocks are based on Mehnert (1968).

INTERNAL INTRUSIVE ROCKS

Mafic Dikes (Unit 8)

Rare, fine-grained, dark green to black, pyritic to non-pyritic dikes of irregular strike intrude the rocks of the Central Domain. The dikes are 1 to 3 m wide and only traceable for a few meters and consequently, are easily overlooked while field-mapping. Some dikes occur on the shore of the lake close to the southwest end of Horseshoe Lake and a few others were noted in outcrops along the rapids south of Horseshoe Lake. Similar dikes were found in the gneissic rocks on Horseshoe Lake north of the belt. If the dikes within the gneissic rocks are of

the same group, then the mafic dikes are considerably later than the metavolcanic rocks.

Only samples from three separate dikes within the Central Domain were analyzed (Table 6). They are quartz normative rocks which project as Mg-rich tholeiitic basalt and calc-alkalic basalt on the Jensen Cation Plot (Figure 6). They differ from the tholeiitic extrusive rocks because of their higher silica and potassium contents and they have a total iron content of less than 10 percent (see Table 4). Unlike the calc-alkalic rocks with similar silica and magnesium content (ie. C3, Table 5) the mafic dikes are lower in aluminum and titanium and higher in potassium, chrome and nickel.

In thin section, the mafic dikes consist of 50 to 60 percent fibrous sheaves of 0.1 to 1 mm long actinolite accompanied by 2 to 5 percent euhedral hornblende and 5 to 10 percent biotite. The remainder of the rock consists of interstitial quartz and albite plus 0.5 to 3 percent, 0.01 to 0.05 mm sized grains of disseminated magnetite and pyrite.

Lamprophyre Dikes (Unit 16b)

Lamprophyre dikes occur near the mouth of the Pipestone River into Horseshoe Lake and appear spatially related to the more felsic perthite-bearing porphyry dikes. No chemical analyses were made of these rocks. They are pinkish grey, fine-grained, micaceous rocks that contain of 50 to 60 percent, 0.01 to 0.5 mm long biotite grains. Grains of epidote and chlorite occur in the interstitial quartzo-feldspathic groundmass.

Perthite and Quartz-perthite-phyric Dikes (Unit 15h)

Perthite and quartz-perthite-phyric dikes form a group of north to north-northeast trending, 1 to 30 m wide dikes, that cut the supracrustal rocks of the Central Domain. They also occur on strike farther south where they cut the gneissic rocks south of the belt.

The dikes are light grey, massive to gneissic rocks. The massive rocks are composed of 25 to 35 percent 0.1 to 1.5 cm sized subhedral to euhedral perthite phenocrysts, 25 to 35 percent subhedral 0.1 to 1 cm plagioclase (An10-20) phenocrysts, and 5 to 10 percent 1 to 5 mm long biotite phenocrysts. These phenocrysts are set in a matrix of 0.1 to 05 mm sized interlocking grains of quartz, feldspar, carbonate, muscovite and biotite. In some dikes glassy, equant quartz phenocrysts up to 4 mm in size, form as much as 10 percent of the rock. The quartz phenocrysts, unlike those in the subvolcanic quartz-feldspar porphyry dikes of the Calc-alkalic Domain, are not bipyramidal nor are they deeply embayed by matrix material. Both the perthite and plagioclase phenocrysts show partial alteration to muscovite, calcite, quartz and albite particularly along their grain boundaries. Small grains of pyrite and magnetite are associated with the biotite grains.

In the gneissic dikes the phenocrysts form augen in which the feldspar grains are fractured and more strongly altered than in the massive dike rocks and the quartz phenocrysts are

strained. The biotite grains are bent around the augen and areas of carbonate and muscovite and quartz occur in the augen shadows.

Granitoid Stocks
(Units 9a and 15a)

A trondhjemite stock (Unit 9a) is one of two stocks of granitoid rock found within the Horseshoe Lake Greenstone Belt. This stock is about 400 m long by 120 m wide and occurs 1.6 km west, southwest of Horseshoe Lake in the Central Domain. The rocks of the stock are leucocratic, white to light grey in colour, weakly gneissic, 2 to 3 mm grained and equigranular. The rock comprises 60 to 70 percent, 1 to 2 mm subhedral plagioclase grains interlocked with one another, 20 percent, 0.1 to 1 mm sized quartz grains and 5 to 10 percent, 0.1 to 0.5 mm long laths of biotite. The plagioclase is oligoclase to albite in composition and is partly altered to sericite and carbonate, particularly along grain boundaries. These two alteration minerals along with the quartz and biotite occur also interstitial to the plagioclase. No K-feldspar was detected in the rock.

On the map (in back pocket) the trondhjemite stock is included with the subvolcanic calc-alkalic rocks because of rock colour and composition (Unit 9a). The stock may represent an isolated, deeply eroded felsic subvolcanic calc-alkalic intrusion or alternatively, it may represent a phase of the early gneissic granitoid rocks (Unit 14, on the map) (back pocket).

The second granitoid stock (Unit 15a) is a granodioritic, massive to weakly gneissic equigranular 800 m diameter body located at the east end of Kecheokagan Lake. It forms an irregular intrusive contact with the granitoid gneiss to the west and with the metavolcanic and metasedimentary rocks of the Central Domain to the east. A mylonite shear zones truncates the stock on its south side.

In the stock, the rocks are mainly pink leucocratic granitoids comprised of 70 to 80 percent, 2 to 3 mm, interlocking grains of oligoclase and perthite in a ratio of about 2 to 1. The remainder consists of 0.5 to 1 mm grained interstitial quartz and minor muscovite. The feldspar grains are fractured and recemented by interlocking quartz and albite grains along millimeter bands which give the rocks their weakly gneissic textures in many places.

Within the stock, many outcrops contain white, siliceous, 1 to 2 mm grained, quartz-rich zones that in places, contain numerous 1 to 2 mm sized brown garnet crystals. The zones are 0.5 to 10 m wide and extend across most outcrops. Laterally, they appear to grade into granodiorite and show no preferred strike direction between outcrops.

Scattered, irregular, meter-wide pegmatite dikes comprised of 2 to 3 cm sized perthite, plagioclase, quartz and muscovite books cut the granodiorite stock. In places, these dikes also contain 1 to 2 mm sized, brown garnet.

Diabase Dikes

(Unit 16a)

Diabase dikes are the youngest rocks in the Horseshoe Lake area. The largest dike located south of Wapamisk Lake, is up to 50 m wide and strikes at 300o for 1.2 km. It cuts the tholeiitic metavolcanics of the Central Domain. A second small of diabase was located on the southwest shore of a small lake 500 m east of central Horseshoe Lake.

Both dikes have the same texture and composition. They consist of 40 to 45 percent, 1 to 4 mm long clinopyroxene, 50 to 55 percent 0.5 to 2 mm long laths of plagioclase (An50-60) and 3 to 5 percent, 1 to 2 mm grained magnetite. The pyroxene ophitically encloses the plagioclase and the magnetite is interstitial to the pyroxene and plagioclase. Edges of the pyroxene and plagioclase grains show deuteric alteration to form chlorite and saussurite, respectively.

EXTERNAL GNEISSIC ROCKS

Introduction

The Horseshoe Lake Greenstone Belt is enclosed to the north, west and south by gneissic rocks mainly of granitoid composition which are intruded in the south part of the map area by batholiths of syenogranite and monzogranite. The author believes that the gneisses were formed as a result of partial melting of supracrustal rocks accompanied by penetrative deformation and the injection of some felsic magma. Within the supracrustal series, the tholeiitic basalts, quartz arenites and cherts were more resistant to partial melting than were the calc-alkalic basalts

and andesites and the other metasedimentary rocks, and accordingly, have remained as recognizable blocks within the granitoid gneisses. Supracrustal rocks that belonged to the Horseshoe Lake Greenstone Belt therefore likely formed a large part of the protolith of the surrounding gneisses.

The gneissic granitoid rocks are subdivided into gneisses of metasedimentary, tholeiitic and calc-alkalic volcanic protolith (Units 10, 11, and 12, Map , back pocket). This interpretation is based on mineralogy and textures observed at localities where the three above groups of supracrustal rocks grade into the gneissic granitoids. At these locations, the mix of supracrustal rock and gneissic granitoid rocks can be described as migmatites or inhomogeneous anatectites. The granitoid gneisses formed within these rocks have mineral contents that partly reflect the mineral composition of the protolith. The paragneisses (Unit 10) are mica-rich, quartz-rich and grade into mica-rich and quartz-rich clastic metasedimentary rocks. The gneisses of tholeiitic volcanic protolith (Unit 11) are mafic to intermediate orthogneisses that contain dark green to black hornblende and in places, magnetite. These rocks contain numerous remnants of tholeiitic basalt and are in contact with the tholeiitic metabasalts of the Horseshoe Lake Greenstone Belt proper. The gneisses of calc-alkalic protolith (Unit 12) are intermediate to felsic orthogneisses in which the hornblende grains are light green and in places accompanied by light green epidote. They grade into the calc-alkalic metavolcanic rocks of the Calc-alkalic Domain. A fourth group of gneisses called gneissic

anatectites (Unit 13, Map , back pocket), possibly represents a mix of partially melted metasedimentary, tholeiitic metavolcanic and earlier formed granitoid rocks (Unit 14). If the author's interpretation is correct, distinguishing the gneissic rocks according to their protoliths would provide clues to the original extent of individual supracrustal rock-groups and the timing of tectonic events that have affected the supracrustal rocks and their enclosing gneisses.

Distribution and Contact Relationships

Paragneiss (Unit 10) of clastic sedimentary protolith occupies much of the area west and north of the Horseshoe Lake Greenstone Belt. The paragneiss extends into the northwest end of the belt where it is interlayered with non gneissic clastic metasedimentary rocks. Eastward the contact zone between the paragneisses and the rocks of the greenstone belt proper narrows into a zone of strong deformation.

A narrow zone of paragneiss also occurs in contact with the metasedimentary rocks of the southern Domain on the southside of the Horseshoe Lake Greenstone Belt.

The orthogneisses interpreted to be derived from tholeiitic metavolcanic rocks (Unit 11) are all located on the south side of the Horseshoe Lake Greenstone Belt except for a few narrow bands within the paragneisses north of the belt. South of the belt, mafic to intermediate gneisses are interbanded with gneissic anatectites (Unit 13). A few limited bands of paragneiss also

occur in contact with the orthogneisses south of the Horseshoe Lake Greenstone Belt.

A few enclaves of the early gneissic (Unit 14) are preserved in the anatectites of unit 13 and between these gneisses and the southern batholith of K-rich late gneissic to massive granitoid rocks (Unit 15). The late granitoid rocks appear to be associated with extensive K-metasomatism of the gneissic granitoid rocks on the south side of the Horseshoe Lake Greenstone Belt.

The remaining group of granitoid rocks consist of gneissic granitoid rocks interpreted to be derived from calc-alkalic volcanic rocks (Unit 12) which occurs along the north margin of the Calc-Alkalic Domain. These gneissic rocks occupy a limited area which suggests that the calc alkalic rocks did not extend much farther north prior to the formation of these granitoid gneisses in this portion of the Horseshoe Lake Greenstone Belt or subsequently, these granitoid gneisses have been truncated by faulting and displaced elsewhere.

The generally poor exposure of the external gneissic rocks greatly hampers understanding their relationships with one another. For example, the contact between the paragneiss on the north side of the Horseshoe Greenstone Belt and the mafic to felsic orthogneisses from tholeiitic metavolcanic protolith on the south side is unexposed west of the belt. It is assumed by the author that the two groups of rocks are of the same age and in gradational contact because no major fault zone extends east into the supracrustal rocks and the metasedimentary and the

metavolcanic rocks are interlayered at the west end of the belt. Instead, the metavolcanic metasedimentary succession appears to grade into both types of granitoid gneisses towards the west.

East-trending curvilinear faults zones, similar to those which form the boundaries between geological domains within the Horseshoe Lake Belt, occur in the granitoid gneisses both north and south of the belt and separate the gneisses of interpreted different protoliths. Some of these fault zones extend from the gneissic rocks into the supracrustal rocks. Toward these fault-contacts, the gneisses become augen gneisses. It is possible that the linear zones of distinctive gneissic rock-types south of the belt were juxtaposed by fault displacement. The contacts between the gneisses are marked by the development of wide zones of augen gneiss to suggest that deformation was not restricted to narrow zones as seen in the supracrustal rocks.

The north and south contact zones between the supracrustal rocks of the Horseshoe Lake Greenstone Belt and the external granitoid gneisses are rather narrow gradational 1 to 10 m wide zones in most places, particularly between the metavolcanic rocks and the gneisses. Dikes of granitoid mobilizate penetrate the supracrustal rocks for distances of less than 10 m from the contacts between the gneisses and the metavolcanic rocks. This sharp transition from orthogneiss to metavolcanic rock occurs along the north shore of Kecheokagan Lake between the tholeiitic metavolcanic rocks and the mafic to intermediate orthogneisses and along the north shore of southeast Horseshoe Lake between the

calc-alkalic metavolcanic rocks and the intermediate to felsic orthogneisses.

The transition from the metasedimentary rocks proper into paragneiss is more gradual both in the southern Domain and in the northwest parts of the Central and Northern Domains. The transition ranges from 10's of meters wide in the Southern Domain to kilometers wide in the Central and Northern Domains. Eastward, along the northern boundary of the Northern Domain, the transition width from metasedimentary rock to paragneisses appears to be shortened by a coinciding deformation zone and intense mylonitization is observed in the rocks of the transition zone.

Paragneisses

(Unit 10)

The paragneisses are mainly grey to pink coloured micaceous gneisses of tonalitic composition. These rocks grade from the north and west into metasedimentary rocks of the Horseshoe Lake Greenstone Belt where they appear interlayered with non gneissic clastic metasedimentary rocks over a wide area. Inside the Horseshoe Greenstone Belt proper no gneissic rocks have been observed. The interlayering of paragneiss and non gneissic metasedimentary rock is the result of primary interlayering of sedimentary rocks of which some types of interbeds were more susceptible to metamorphic recrystallization than others.

The less mobilitized metasedimentary rocks are only weakly recrystallized, but internal primary textures and structures

except for bedding contacts and their granular textures, have been destroyed. These recrystallized metasedimentary rocks consist of 0.5 to 2 mm grained, granoblastic rocks composed of different proportions of idioblastic biotite or muscovite with interstitial xenoblastic quartz and subordinate oligoclase. Relict clastic quartz grains are deformed and remain as lenticles comprised of numerous xenoblastic quartz grains enclosed by mica which gives the rocks a granular texture.

The paragneissic rocks interlayered with the only recrystallized non gneissic metasedimentary rocks just described are coarse, 2 to 3 mm grained, grey to pink, crystalline rocks. They consist of subhedral biotite, oligoclase and minor orthoclase interlocked with anhedral quartz. In most rocks the biotite forms subparallel lenticles 2 to 5 mm long, orthoclase shows partial alteration to sericite, and the quartz is finer grained and fills the intergranular spaces among the feldspars. In some gneisses, muscovite is more abundant than biotite.

On the outcrop, the paragneisses exhibit banding. This banding is either the result of metamorphic insitu segregation or represents relict primary sedimentary bedding accentuated by anatectic mobilization. The banding is mainly caused by changes in biotite content and the variation of colours from gray to pinkish orange. The thickness of the bands is similar to that in beds of nearby non gneissic metasedimentary rocks. In many outcrops, it is difficult to draw a sharp boundary between banded paragneiss and bedded metasedimentary rock.

In places, the paragneisses contain discordant layers of gneissic granitoid mobilizate that extend into the non gneissic metasedimentary rocks. These layers are from 2 cm to 2 m wide of varied length and most follow a nearly constant strike. They range from 1 mm grained to 10 mm grained and are from weakly gneissic to strongly gneissic with quartz-plagioclase augen enveloped by a thin layer of mica. They consist of mainly oligoclase and quartz with minor orthoclase, biotite and muscovite.

Going westward and northward from the northwest part of the Horseshoe Lake Greenstone Belt, the paragneisses become more abundant at the expense of the non gneissic metasedimentary rocks. The layers of the non gneissic metasedimentary rocks become thin and disconnected lenses until they can only be recognized as irregular schistose to gneissic remnants in the paragneisses. Little change occurs in the paragneisses except that banding becomes more diffuse in most places.

Across the northern part of the map area, the paragneisses are weakly to strongly banded biotite-quartz-feldspar gneisses and muscovite-quartz-feldspar gneisses. The banding is mainly the result of variations in mica content, grain size and colour from grey to pink. Most of the gneisses contain 45 to 60 percent oligoclase, 30 to 35 percent quartz, 2 to 10 percent mica, either biotite or muscovite and minor K-feldspar. The micas and feldspars are subaligned to give the rocks their gneissic texture.

Within the paragneisses remnants of mainly metasedimentary rocks occur. They range from mica-rich schists to mylonitized chert. Some chert remnants extend into irregular quartz-veins that probably originated by the recrystallization of the chert to coarser-grained quartz. The abundance of remnants as well their size, varies from area to area within the paragneiss. On Horseshoe Lake, outcrop can be observed with up to 50 percent remnants that range from 2 cm to 2 m in size. In other outcrop, the remnants can form a large single lens several meters long parallel to the strike of the regional gneissosity. In most outcrops, where numerous remnants are present, the remnants are approximately of the same composition. In a few outcrops, rare xenoliths can be identified as tholeiitic basalt to suggest the protolith had subordinate amounts of metavolcanic rock.

Most outcrops of paragneiss contain lenses and discordant bands of leucocratic mobilizate from 5 cm to 10 m wide which can only be distinguished from the paragneisses where grain size, colour, and mineral differences exist or the mobilizate cross-cuts metasedimentary remnants. In places, the mobilizates appear to grade into the enclosing paragneisses. The mobilizates tend to be coarser grained and plagioclase-phyric with less biotite and quartz than the enclosing paragneisses. They consist of 70 to 80 percent subhedral interlocking grains of albite or oligoclase with 20 percent interstitial smaller sized anhedral quartz grains with minor muscovite or biotite. Some partly sericitized perthite or orthoclase occurs in many of the mobilizate rocks, particularly in mobilizates which have a gneissic texture.

Mafic to Intermediate Orthogneisses
(Unit 11)

The mafic to intermediate orthogneisses are melano- to mesocratic gneisses interpreted to be derived from tholeiitic volcanic protolith. They range from gabbro to granite (sensu stricto) in composition. They are distinguished from the other groups of gneissic rocks by their dark green to black iron-rich hornblende. Many rocks of this group of gneisses are no less felsic than rocks within other groups of gneisses, except that they tend to be less quartz-rich than the paragneisses. Their dark green to black mafic minerals skews their field colour index towards being mesocratic and melanocratic by masking the smaller felsic grains.

Two large zones of mafic to intermediate hornblende-bearing orthogneisses occur south of the Horseshoe Lake Greenstone Belt. The first zone occurs in contact with the supracrustal rocks of the Central Domain for the length of Kecheokagan Lake and the second occurs farther south, which connects narrow remanent bands of tholeiitic volcanic rock, located south of the Horseshoe Lake Greenstone Belt proper. One greenstone remanent is located along the Pipestone River southwest of Kecheokagan Lake where it contains iron-formation and chert interlayered with Mg-rich tholeiitic metabasalt and the second one occurs 3 km south of Horseshoe Lake along Longitude 90°45', and is composed of Fe-rich tholeiitic basalt. The connecting mafic to felsic hornblende-

bearing gneisses can be traced as a magnetic high on aeromagnetic map 916G (ODM-GSC, 1960).

Most of the mafic to intermediate hornblende-bearing gneisses south of the belt, have undergone K-metasomatism and deformation. This has transformed the more felsic rocks from tonalitic compositional gneisses comprised of mainly interlocked hornblende, quartz and plagioclase into biotite and chlorite-bearing granite gneisses with K-feldspar augen stained by ferrous to ferric iron oxide. Although most of the gneisses of gabbroic composition have undergone some deformation, they appear to have been less permeable to the K-metasomatism causing fluids.

The mafic hornblende-bearing gneisses are melanocratic rocks of gabbroic composition. These gabbroic orthogneisses consist of 30 to 50 percent anhedral to subhedral 2 to 3 mm sized tabular to elongate, twinned hornblende, 30 to 60 percent, 2 to 4 mm long, white, subhedral tabular plagioclase of andesine composition, 5 to 10 percent 0.1 to 1 mm subhedral quartz and 2 to 5 percent, and .01 to 0.5 mm sized magnetite. The interlocking hornblende, quartz, and magnetite grains occur interstitial to the plagioclase. Where deformated, the gabbroic orthogneisses are augen gneisses in which the interstitial hornblende, quartz and magmatite become aggregates fine-grained, fractured hornblende and recrystallized quartz with additional grains of plagioclase, biotite and minor K-feldspar that surrounds the larger, rounded plagioclase clasts. The edges of the largest hornblende grains are replaced by biotite that is partly altered to chlorite.

The best preserved melanocratic gneisses of gabbroic composition surround the greenstone remnant 3 km south of Horseshoe Lake. Elsewhere, they are partly to strongly deformed and form bands and zones within intermediate orthogneisses and augen gneisses. In places they grade into the intermediate gneisses.

The mesocratic orthogneisses of rock unit 11 consist of 10 to 30 percent anhedral to subhedral, 2 to 4 mm sized tabular to elongate shaped, dark green, twinned hornblende 50 to 60 percent subhedral, 3 to 5 mm long tabular to elongate plagioclase of andesine to oligoclase composition, 10 to 15 percent, 1 to 3 mm sized anhedral quartz and 1 to 2 percent, 0.1 to 0.5 mm sized magnetite. Like in the more mafic gneisses, the hornblende, quartz and magnetite occur interstitial to the larger plagioclase grains. Where K-metasomatism has affected the rocks, the hornblende is partly replaced by biotite that is partially altered to chlorite, and K-feldspar grains are formed interstitially to the plagioclase and replace portions of the plagioclase. In most places, the K metasomatism is accompanied by deformation which caused fracturing of the institial hornblende and biotite and the stretching of these minerals to form mafic lenticles between the larger rounded feldspar.

In the most extensively deformed and metasomatized mesocratic gneisses, all the plagioclase and hornblende grains are replaced by K-feldspar porphyroclasts up to 1 cm size and dark green, chloritized biotite respectively. In the most deformed rocks, the K-feldspar porphyroclasts form fractured

augen enclosed by aggregates and stringers 1 to 3 cm wide of fragmented quartz, biotite and albite. In some rocks, the larger biotite grains retain relict cores of hornblende. Best exposures of these rocks occur on the shores of Kecheokagan Lake where deformation, in part, post dates the K-metasomatism of the orthogneisses.

The remnants within the mafic to intermediate orthogneisses are mainly tholeiitic metavolcanic rocks and are from 0.10 to 5 m across. Most large remnants are brecciated near their margins and have fractures filled by plagioclase and quartz to form agmatite structure.

Agmatic structure is present in many locations along the contact zones between the mafic to intermediate orthogneisses and the mafic tholeiitic metavolcanic rocks. The dark-coloured metavolcanic rocks have fine to coarse net-like fracture patterns in which the fractures are filled with light-coloured feldspathic mobilizate 0.5 to 2 cm wide. The agmatic structure is well developed in many of the 1 to 2 cm grained rocks with hornblende pseudomorphs after pyroxene in which feldspathic mobilizate follows selected grain boundaries. In many of these rocks, the agmatic structure is closely associated with rocks in which leucocratic feldspar and quartz have developed interstitial to the hornblende pseudomorphs after pyroxene. The agmatic structures grade into mafic orthogneisses.

. The mobilizate dikes and lenses within the orthogneisses described here are mainly leucocratic massive to gneissic, fine-grained to 4 mm grained rocks comprised of 70 to 80 percent

feldspar, 15 to 25 percent quartz and minor hornblende or biotite. They range from plagioclase rich rocks to K-feldspar rich rocks and cut one another as well as the mafic to intermediate orthogneisses.

Intermediate to Felsic Orthogneisses
(Unit 12)

The intermediate to felsic orthogneisses are leucocratic to mesocratic and interpreted by the author to be derived from a calc-alkalic metavolcanic protolith. They are distinguishable from the gneisses derived from the Fe-rich tholeiitic metavolcanic protoliths by their light apple-green hornblende. In most places, the light green hornblende is accompanied by epidote and chlorite to form a light pinkish green gneiss.

The transition of calc-alkalic metavolcanic rock proper into hornblende orthogneisses is best exposed on the north shore of southeast Horseshoe Lake. The transition begins with development of fine-grained, interlocking grains of equigranular quartz, albite, epidote and hornblende aggregates interstitial to and partly at the expense of the larger strongly altered primary plagioclase and pyroxene grains which comprise the calc-alkalic metabasalts. Where the growth of these new minerals is uniform, the metabasalts become metablastic and over a few meters from the calc alkalic basalts proper, they grade into more uniform weakly banded gneisses. The gneisses are comprised of 60 to 75 percent, 1-3 mm subhedral andesine, 10 to 20 percent, 1-2 mm hornblende associated with epidote and minor chlorite and biotite, and 5 to

20 percent 0.1 to 2 mm size quartz. The subparallel hornblende grains as well as epidote and quartz grains occur interstitial to the plagioclase and as lenticles in the gneisses. The weak banding observed in the orthogneisses are the result of minor changes in colour, grain size and mafic mineral content as the rocks vary from intermediate to felsic in composition. Very few remnants of basalt remain in the gneissic rocks.

In places where the transition from calc-alkalic metavolcanic rock to intermediate orthogneiss is less gradational, agmatic structures are present. The calc-alkalic metavolcanic rocks are brecciated and leucocratic feldspathic mobilizate fills the fractures. As the rocks grade from calc-alkalic metavolcanic rocks proper into orthogneiss, the fractures become more closely spaced and the fragments of volcanic rock become recrystallized exhibiting (in thin section) a gneissic textured of interlocking quartz, albite and hornblende.

The maximum width of the intermediate to felsic granitoid gneisses displaying the light green hornblende and epidote is less than 600 m wide, north of the southeast end of Horseshoe Lake. The gneisses narrow and pinch out towards the west and farther east, the gneisses are unexposed. To the north, a faulted contact is indicated by an abrupt change from intermediate to felsic orthogneiss to paragneiss. Toward this contact the orthogneisses become augen gneiss in their most northerly outcrops. The augen gneiss consists of the 2 to 5 mm, strongly fractured plagioclase augen which are partly to completely altered to sericite. The plagioclase augens are in a

matrix composed of lenticles of fine interlocking quartz and albite grains that alternate with lenticles of matted sericite and chlorite in which relict fragments of hornblende and epidote remain. The plagioclase and hornblende grains show rotation in the finer grained matrix of quartz and sericite. Little or no K-feldspar occurs in either the intermediate to felsic orthogneisses or the augen gneisses.

Gneissic Anatectites

(Unit 13)

The gneissic anatectites represent a heterogeneous suite of melano-to leucocratic gneisses. The protoliths of these rocks probably were metasedimentary and mafic tholeiitic metavolcanic rock and possibly some early tonalitic granitoid rocks. They underlie large portions of the gneissic terrain south of the Horseshoe Lake Greenstone belt between the narrower zones of mafic to intermediate orthogneisses derived from tholeiitic metavolcanic rock. As a group, the gneissic anatectites contain a wider variety of migmatitic structures and rock phases than do the previously described groups of gneisses and may have had a more complex history of development. In places, like the mafic to intermediate orthogneisses, they have undergone late deformation accompanied by K-metasomatism.

The anatectites as found in the map area range from rather homogeneous migmatites to complex migmatites exhibiting polyphase remobilization and deformation. The homogeneous migmatites are 2 to 5 mm grained, melanocratic to leucocratic, hornblende to

biotite-bearing gneisses in which either plagioclase or K-feldspar forms their main felsic component. In places, these homogeneous migmatites resemble the above described groups of gneisses but lack compositional continuity. Instead the homogeneous migmatites have constant compositions over limited distances within the anatectites and exhibit all variations in the proportions of the rock forming minerals. Where deformed, they form augen gneiss.

The complex migmatitic rocks are mainly banded and layered gneissic rocks comprised of millimeter thick monomineralic layers to meter thick layers of the above gneisses with associated layers of pegmatitic leucosome mobilizate. The most mafic paleosome tend to occur in bands of constant thickness whereas leucosome layers have pinch and swell structures. In many places the bands are complexly folded and faulted and are discontinuous or grade into nebulitic migmatite (Mehnert, 1968). The leucosomes are contorted and complexly folded to ptygmatic and in some outcrops, cross cut the banded paleosome.

In some places, the banded gneiss have agmatic structures where the fragments of banded rock appear to float freely in the leucosome and undergoing partial assimilation (Photo 15).

Remnants of the protoliths, are mainly .1 to 5 m sized subangular blocks of tholeiitic metabasalt similar to the tholeiitic metabasalts of the Central Domain of the Horseshoe Lake Greenstone Belt. Amongst these remnants of metabasalt are Mg-rich tholeiitic basalts that contain pyroxene phenocrysts up to 2 cm in size. Smaller biotite-rich quartz-bearing

metasedimentary remnants similar to the interflow metasedimentary rocks of the Central Domain also occur with the metavolcanic remnants. The remnants mainly occur in homogeneous, weakly gneissic leucosome rather than in the strongly banded gneiss and many of the larger mafic metavolcanic remnants are undeformed and unaffected by K-metasomatism.

Numerous 1 to 5 m wide massive to weakly gneissic dikes of K-feldspar-rich leucocratic mobilizate cut the anatectites. They are 1 to 4 mm grained rocks comprised of 60 to 75 percent perthite, and 15 to 25 percent quartz with minor biotite, muscovite and in places magnetite.

GRANITOID ROCKS

Early Gneissic Granitoid Rocks

(Unit 14)

The early gneissic granitoid rocks are mainly 1 to 2 mm grained, light grey to pink rocks considered to have been emplaced as intrusive bodies during the development of the previously described gneisses. They mainly underlie areas south of the gneissic anatectites where they appear to be intruded by late syenogranite and syenomonzonite. The early gneissic granitoids also form small elongate stocks within the orthogneisses in areas close to the supracrustal rocks and in part, may have been responsible for the mobilizate portions of these gneisses. In places, the early gneissic granitoids contain xenoliths of similar texture and composition to remnants within the orthogneisses.

The early gneissic granitoids are distinguished from the other granitoids by their greater homogeneity and low K-feldspar content. The more felsic varieties are trondhjemites which have 1 to 5 percent, sub-aligned 0.5 to 1.5 long hornblende and biotite, 15 to 25 percent, subhedral 1 to 2 mm quartz and 70 to 80 percent, 1 to 2 mm sized, subhedral plagioclase of oligoclase composition. The mafic minerals and quartz along with minor magnitite and accessory apatite and titanite occur interstitial to the plagioclase. The plagioclase is partly saussauritized to form fine-grained sericite and albite. In some rocks, the plagioclase form zoned 3 to 5 mm, subhedral to euhedral phenocrysts interlocked with smaller plagioclase crystals.

The more mafic phases of early granitoid rocks are not abundant and are coarse, 2 to 4 mm grained tonalites and quartz diorites which contain 5 to 15 percent hornblende and plagioclase of andesine composition. They and the trondhjemites cut one another.

Late Granitoid Rocks

(Unit 15)

Late granitoid rocks occur in the south parts of the map area. These rocks occur in the north part of a large composite batholith of monzogranite and syenogranite that mainly occurs south of the map area. Most outcrops consist of two or more cross-cutting phases of monzogranite that are cut in turn by fine grained leucocratic dikes and pegmatite dikes. In places, particularly in the vicinity of the Morris River, pegmatite is

the main rock type in many outcrops. It forms numerous 1 to 10 m wide cross-cutting dikes so that in places, little or nothing of the host monzogranite remains.

The monzogranites are mainly equigranular, 2 to 3 mm grained, pink to red coloured rocks. They consist of 20 to 25 percent anhedral to subhedral orthoclase, 20 to 25 percent anhedral to subhedral plagioclase of oligoclase composition, 20 to 30 percent anhedral quartz, and 15 to 25 percent anhedral perthite, all of about the same grain size. Subhedral biotite, muscovite and in places hornblende along with accessory apatite, zircon, and titanite form the remaining 1 to 3 percent of the rock. The plagioclase and orthoclase show saussuritization and sericitization respectively, particularly along fractures, and at the edges and in the cores of grains. The perthite and antiperthite grains are unaltered and poikilitically enclose smaller grains of quartz, albite, and orthoclase. Some small grains of perthite marginal to the larger perthite grains have graphic intergrowths of quartz. Quartz mainly occurs as interlocking grains among the feldspar grains. The mafic minerals and accessory minerals form small clusters with the quartz.

The pegmatites associated with the late granitoid rocks are composed of 60 to 80 percent, 1 to 20 cm sized, subhedral perthite and microcline crystals that contain graphic intergrowths of quartz. Quartz and minor albite fill the spaces between the large feldspar crystals and centimeter-sized books of

muscovite occur scattered throughout many dikes. Rare, 0.1 to 2 cm sized grains of magnetite also occur.

Xenoliths 0.1 to 1 m in size of metasedimentary, tholeiitic metavolcanic and tonalitic composition are numerous in many outcrops of the batholith, particularly in the southwest part of the map area. The supracrustal xenoliths have sharp angular contacts with the monzogranites and most appear as isolated floating blocks. Relict bedding is preserved in some of the metasedimentary xenoliths. The tonalitic xenoliths form isolated blocks which are more resistant to weathering and have positive reliefs on the outcrop surface. They are more mafic, have less K-feldspar than the host rocks, and have gneissic textures.

CENOZOIC

QUATERNARY

Pleistocene Deposits

Pleistocene glaciation striated, grooved and eroded the bedrock and removed all traces of earlier soil and weathered rock. The last and most dominant ice movement to affect the area was from the northeast at about 220° (+-20°) azimuth as suggested by glacial striae (Finamore and Carswell, 1986). This last glacial advance occurred less than 10,000 years ago and laid down a variety of discontinuous unconsolidated Wisconsinan deposits during its advance and subsequent retreat.

Recent erosional cuts reveal that lodgment till from the advance of the glacier and ablation till from the melt out of the glacier during its retreat, covers much of the areas where

bedrock exposures are present. Both types of tills are yellowish brown to brown coloured and sandy textured with numerous well rounded pebble to boulder size clasts. In places, the tills partly to completely mantle outcrops to form boulder covered drumlin-shaped hills. In most places the till is less than 2 m thick (Finamore and Carswell, 1986).

Eskers of an orientation similar to the glacial striae are numerous in the vicinity of Sasiginaga Lake and south of the Horseshoe Lake Greenstone Belt. A 19 km long esker extends west southwest from north of the southeast arm of Horseshoe Lake diagonally across the Horseshoe Lake Greenstone Belt and across Kecheokagan Lake. This esker extends from the Agutua Moraine (Prest, 1963) located in the northeast part of the map area. This morain is mainly composed of glaciofluvial and detaic sediments (Finamore and Carswell, 1986).

Wave action of glacial Lake Agassiz removed the till cover of many bedrock highs, leaving only the largest boulders. Small sandy elevated beaches are present around some outcrops. Much of this reworked material appears to have been deposited in low lying areas. Some lacustrine sand overlies the till units along eroding shorelines.

Varved clay and parabolic sand dunes were not found in the map area.

RECENT DEPOSITS

Deposits of peat are found in bogs, swamps and meandering waterways. They cover extensive areas south of the Horseshoe

Lake Greenstone Belt. The larger bogs contain areas of fen considered to be relict collapse scars that may have formed in thermokarst peat plateaus (Mollard and Janes, 1984).

On well drained elevated areas, organic soil cover is only 1 to 5 cm thick.

Land erosion is minor along streams and shorelines because of the mature landscape topography.

METAMORPHISM AND METASOMATISM

INTRODUCTION

All of the supracrustal rocks of the Horseshoe Lake Greenstone Belt as well as many of the external granitoid gneisses have been affected to different degrees by metamorphism. In several places these rocks have undergone metasomatism as well as metamorphism. In the preceding descriptions of the rock types, references have been made to the metamorphic grades and mineral changes caused by metasomatism. The main aim of this part of the report is to describe the distribution of metamorphic grades and timing of the metamorphism and metasomatism and their possible association with periods of magmatism and deformation.

Recognition of metamorphic facies is based on the index minerals of Winkler (1967). Where possible, the metamorphic mineral assemblages of two or more rock types with the same area have been studied to determine the metamorphic grade of a given area.

The recognition of metasomatism is based on mineral or chemical changes caused by the addition or subtraction of mobile

agents in rock types that elsewhere appear to have only undergone isochemical regional metamorphism. This was done by searching for minerals formed by mobile agents such as CO_2, SiO_2, H_2O, K_2O and SO_2 and S through thin section examination, staining and acid tests on numerous hand specimens. Sufficient chemical analyses were not available to make quantified estimates of metasomatic changes that are suspected to have occurred in many zones of more intense deformation.

AREAL DISTRIBUTION OF METAMORPHIC FACIES

In the Horseshoe Lake Greenstone Belt, metamorphic facies changes mainly occur across domain boundaries. Little change in metamorphic grade is observed internally in each geological domain and each domain has its own grade of regional metamorphism.

The metamorphic grades observed in the Southern Domain, the Northern and Central Domains and the Calc-alkalic Domains are lower amphibolite facies, middle to upper greenschist facies and lower greenschist facies, respectively (Figure 7). Only in the west and northwest parts of the Northern and Central Domains does the metamorphic grade change, namely in each of these two domains from upper greenschist to amphibolite facies. This increase in metamorphic grade occurs where the non-gneissic metasedimentary rocks begin to be interlayered with the paragneisses. Under amphibolite grade metamorphic conditions some rock types within the metasedimentary succession were more susceptible to partial mobilization than others and were transformed into paragneisses.

In the west and northwest parts of the Northern and Central Domains, these interlayered paragneisses and amphibolite-grade metasedimentary rocks occupy a wide area between the paragneisses proper and the Horseshoe Lake Greenstone belt proper where as, along the north boundary of the belt, the interlayering of paragneisses and amphibolite grade metasedimentary is less than 500 m wide and here, the increase in metamorphic grade is more abrupt. Similarly, an abrupt increase in metamorphic grade occurs at the contacts between the metavolcanic rocks and the orthogneisses. In places, the metamorphic index minerals of adjoining metavolcanic rocks, such as epidote remain found in the adjoining orthogneisses. The event which was caused by formation of the external gneisses does not account for the differences of metamorphic grade between geological domains and was, therefore unlikely responsible for the pattern of metamorphism in the Horseshoe Lake Greenstone Belt proper.

The regional metamorphism of the supracrustal rocks were mainly isochemical mineralogical changes. In the lower greenschist facies of the Calc-alkalic Domain, the calc-alkalic basalts are composed of albite, epidote, chlorite, quartz, actinolite carbonate and leucoxene mainly derived from the alteration of clinopyroxene and calcic plagioclase. Pseudomorphs of the primary minerals remain so that the primary igneous of the flows and sedimentary textures and tuffs are still recognizable.

Within the Central and Northern Domains, both the tholeiitic metavolcanic and the clastic metasedimentary rocks have undergone regional middle to upper greenschist facies metamorphism. The

diagnostic minerals are rare, porphyroblastic almandine in iron-rich mafic metasedimentary rocks and altered chloritoid porphyroblasts in pelitic metasedimentary rocks (Photo 4). In the 1-3 mm grained tholeiitic metabasalts, the primary igneous textures remain recognizable. In these rocks hornblende pseudomorphs after clinopyroxene ophitically enclose albite pseudomorphs after calcic plagioclase. The albite grains contain numerous needle-shaped grains of actinolite. In the more silica-rich, Fe-rich tholeiitic metabasalts, granoblastic quartz occurs interstitial to the pseudomorphic plagioclase along with primary 0.5 to 2 mm grains of magnetite. Abundant secondary 0.01 to 0.5 mm grains of magnetite occur in the hornblende pseudomorphs. Chlorite becomes abundant only in the mafic rocks where they have undergone retrograde metamorphism accompanied by metasomatism along zones of deformation.

The clastic metasedimentary units and interflow sediments in the Central and Northern Domains, like the tholiitic flows, retain their primary textures within the upper greenschist facies. Mineral clasts of quartz and feldspar retain their size and shape within a fine-grained matrix of granoblastic biotite, quartz, albite, and in places, actinolite, a muscovite and magnetite.

The transition from middle and upper greenschist facies to lower amphibolite rank metamorphism in the Central and Northern Domains is marked by the development of equant hornblende crystals and the transition from albite to andesine composition in the plagioclase of the tholeiitic basalts, accompanied with a

partial loss of their original igneous rock texture. In the clastic metasedimentary rocks, the transition is marked by the incorporation of the clastic quartz and plagioclase into the granoblastic matrix of quartz, biotite, andesine and muscovite. In places the plagioclase forms poikiloblasts that contain biotite crystals. Staurolite and other minerals indicative of amphibolite grade metamorphism were not observed, possibly because of the rarity of pelitic sedimentary rocks in the metavolcano-sedimentary succession.

The arkosic metasedimentary rocks of the Southern Domain are of lower amphibolite grade metamorphism. They consist of granoblastic quartz, andesine, biotite, and muscovite. Because of the higher initial abundance of plagioclase, many rocks contain large poikiloblasts of andesine which enclose quartz, biotite and smaller andesine grains.

Metasomatism

The large areas affected by carbonate and potash metasomatism are shown in Figure 7. Occurrences of quartz veining and sulphide concentrations are indicated on the map (back pocket). In addition to the above types of metasomatism, considerable metasomatism is suspected to have occur along many narrow, strongly chloritized fault zones.

Potash metasomatism is mainly recognized in the mafic to intermediate orthogneiss south of the Horseshoe Lake Greenstone Belt. The belt itself, as well as the northern paragneiss have largely escaped this metasomatism. The most likely source of

potash metasomatism were the late K-rich granitoid rocks on the south edge of the map area. Some of these rocks in the form of perthite-phyric dikes extend north and cut the supracrustal rocks and probably were responsible for some potash metasomatism of the supracrustal rocks in places along dikes and fracture zones.

A zone of intensive carbonate alteration occurs in the rocks close to the boundary between the Central Domain and the Calc-alkalic Domain. The blue quartz-bearing unit of iron-rich tholeiitic basalt where sheared, is strongly carbonatized and chloritized as are some of the nearby Mg-rich tholeiitic basalts and metasedimentary rocks. Numerous 1 cm to 20 cm wide quartz veins trending approximately 330 degrees cross-cut the shearing at intervals of 20 to 100 m. The carbonatization occurs along the south shore of Horseshoe Lake and farther west where the blue-quartz unit begins to strike southward around the nose of the anticline. Carbonate is rare in the unsheared, blue quartz-bearing, Fe-rich tholeiitic basalts as well as other rock types, elsewhere in the Central Domain.

Source of the carbonatization in the tholeiitic basalts is uncertain. Carbonate mainly occurs only in sheared and strongly chloritized rocks to suggest that it was introduced during late faulting and shearing after regional metamorphism. Limestone found with the tholeiitic basalts in this area may have been the source of carbonate although the carbonatization seems to extend for much greater distances than the limestone. The other probable source may have been the calcite-rich calc-alkalic

metavolcanic rocks which are juxtaposed against the rocks of the Central Domain for nearly the full length of the carbonatization.

Carbonate is present in all the calc-alkalic rocks, in particular the mafic calc-alkalic tuffs and is a result of the break-down of calcic plagioclase during lower greenschist metamorphism. Some of the carbonate in the tuffs could be primary carbonate deposited with the ash and crystal fragments. Some tuff beds were noted to have high carbonate contents compared with adjoining beds. The tuff beds are more highly schistose than other calc-alkalic rocks and carbonate may have been remobilized.

Carbonate and quartz veining and alternation was noted in many narrow shear zones associated with north east fractures which cut the Central Domain. In places, fine disseminated pyrite is present with the alteration and some alteration zones have been noted to be gold-bearing in the vicinity of the K-rich feldspar and quartz feldspar porphyry dikes.

Structural Geology

Introduction

The Horseshoe Lake Greenstone Belt consists of several geological domain juxtapositioned against each other along distinct domain boundaries. The domains, as described in the foregoing section on the general geology of this report are characterized by distinct rock assemblages. They are also characterized by distinct structural features indicative of several periods of tectonism. These features range from megascopic folds and faults such as the domain boundaries to

meso-and microscopic features like parasitic folds and mineral alignment and fracturing.

The boundaries of the domains are shear zones that range from a few metres to several 10's of meters wide and extend along much of the length of the greenstone belt. They are largely curviplanar, easterly-trending and, in places, extend into the external gneisses. They are referred to as the North Boundary Fault-Zone, Northern Horseshoe Lake Fault Zone, Southern Horseshoe Lake Fault Zone and the Ketcheokagan Lake Fault Zone (Figure 8).

The structural features within each of the geological domains are truncated at the domain boundaries. In all the domains, the supracrustal rocks are steeply tilted or folded and, in places, faulted. Many of the rocks, in particular the fine-grained metasedimentary rocks, display a schistosity subparallel to the bedding surfaces caused by the mineral alignment of biotite, muscovite, chlorite and amphibole. In many places, this planar schistosity is transected or overprinted by slip cleavage planes parallel to subparallel to the fold axial planes and by fracturing along meter to several meter wide fault zones. All these intersections show up as lineations in the rocks.

The bands of para- and orthogneiss external to the Horseshoe Lake Greenstone Belt truncate the structural features of the supracrustal rocks. Only the major fault-zones and some late brittle fault fractures extend from the belt into the gneisses and granitoid rocks. In these external rocks the fault zones are represented by augen gneiss and mylonite. Some of these

deformation zones extend along the boundaries between bands of paragneiss and orthogneiss.

Domain Boundaries

The fault boundaries of the geological domains, namely the Kecheokagan Lake Fault Zone, Southern and Northern Horseshoe Lake Fault Zone and the North Boundary Fault zone are major east-trending curviplanar deformation zones (Figure 8). Most of them are associated with strong shearing of the rocks near the margins of the adjacent domains. In several places, the boundary fault zones bifurcate and have subsidiary splay faults which penetrate the domains and the external gneisses and granitoid rocks.

In the metavolcanic and metasedimentary rocks the shearing associated with the domain boundaries is mainly represented by prominent steeply plunging mineral lineations on subvertical planar fracture surfaces. In the metavolcanic rocks, the minerals which comprise the lineations are chlorite, actinolite and, in places, carbonate and in the metasedimentary rocks, biotite, muscovite, chlorite and stretched grains of feldspar and quartz. The directions of relative lateral movement are decernible by dislocated parasitic folds and partially rotated and stretched pillows and displaced bedding structures.

Where the boundary fault zones intersect more competent felsic metasedimentary rock and granitoid rock, the rocks are mylonitized over widths of a few to several meters. The mylonitic textures consist of rod-shaped quartz and feldspar grains many times their original size. In less felsic para- and

orthogneiss the fault zones are broad zones of augen gneiss. The augen gneisses have a schistose texture imparted on them by biotite, amphibole, muscovite and chlorite which enclose subparallel, fractured, feldspar augen.

The North Boundary Fault Zone in the northwest part of the map area can be recognized as a zone of augen gneisses. It follows a narrow chain of lakes eastward to Horseshoe Lake where it forms the north boundary of the Northern Domain (Figure 8). Along the south shore of these lakes the paragneisses and the quartz rich metasedimentary rocks are mylonitized. In this area, the fault zone coincides with a gradational contact between the metasedimentary rocks and paragneisses. Several southeast-striking conjugate splay faults extend from the main North Boundary Fault Zone to connect with the North and South Horseshoe Fault Zones. These splay faults merge into deformation zones and become the Northern and Southern Horseshoe Lake Fault Zones which separate the calc-alaklic metavolcanic rocks from the rocks of the Northern and Central Domain. East of Horseshoe Lake, the North Boundary Fault Zone strikes east-northeast into the paragneisses in the north part of the map area.

The Northern as well as Southern Horseshoe Lake Fault Zones form intense 10 to 20 m wide shear zones between the Northern and Central Domains and the Calc-alkalic Domain respectively about 4 km west of Horseshoe Lake. West of the Calc-alkalic Domain, where the Northern and Central Domain come in contact with each other, several faults splay off these fault zones into the Northern and Central Domains. Eastward, at Horseshoe Lake, the

Northern Horseshoe Lake Fault Zone extends into the external gneisses where it forms the boundary between the paragneisses and the intermediate to felsic orothogneisses adjoining the Calc-alkalic Domain. Further east it becomes lost under drift cover.

The South Horseshoe Fault Zone extends the length of the southeast arm of Horseshoe Lake between the Calc-alkalic Domain and the Central Domain. On the north side of the fault zone, the calc-alkalic tuffs are intensely sheared and on the south side the tholeiitic metavolcanics are schistose with intense carbonate and chlorite alteration. This fault zone is considered to extend east, through Wapamisk Lake based on exposures of tholeiitic basalt south of Wapamisk Lake and high magnetic anomalies on the north side of the lake that are associated with interbedded iron formation and calc-alkalic tuff as seen in the limited outcrop.

The Kecheokagan Fault Zone extends east under Kecheokagan Lake within the orthogneisses where it coincides with a wide zone of K-metasomatized mafic to intermediate augen gneisses.

Here, the feldspar augen and their enclosing mafic minerals plunge 30° to 50° eastward. East, at the end of the Kecheokagan Lake, the fault zone appears to narrow into a 5 to 8 m wide mylonite zone exposed along the rapids at the outlet of Kecheokagan Lake. This mylonite zone forms the contact between a somewhat deformed granodioritic stock to the north and orthogneiss and Southern Domain rocks to the south and southeast respectively. East of the granodiorite stock, the fault forms the south boundary of the Southern Domain and farther east, the

south boundary of the Central Domain where it becomes lost under drift cover.

In several places, the Kecheokagan Lake Fault Zone bifurcates to form narrow east northeast trending splay faults that transect the Central Domain and join the Southern Horseshoe Fault Zone. The first splay fault east of the granodiorite stock forms the boundary between the Southern and Central Domains.

It is impossible to estimate the amount of relative movement along each of the major shear zones. Some dextral movement is evident from drag folds and rotation and stretching of pillows along the Northern and Southern Horseshoe Lake Fault Zones. However, most of the fracture planes within the fault zones are vertical to subvertical and mineral lineations within the fracture planes mostly plunge vertically to steeply east to indicate vertical movement occurred along the domain boundaries (Photo 19). Subvertical slickensides indicate north side down and south side up at all boundary faults except the Northern - Horseshoe Lake Fault Zone where north side appears to have moved up. In the augen gneisses the mineral lineations commonly have a more shallow easterly plunges. In many places along the Kecheokagan Lake Fault Zone on Kecheokagan Lake, the augen gneiss mineral lineations plunge 30°.

Early Deformation of the Domains

Southern Domain

In the Southern Domain, the metasedimentary strata mainly face southeast, dip steeply southeast, and contain mineral lineations which plunge to the east and northeast. At the east end of the domain, the strike of the strata changes to a southeast direction with vertical to subvertical dips to the northeast. Here, the facing direction is unknown and it is unclear whether a synclinal axis or a fault is present between the two areas of different strike.

The strata of the Southern Domain are truncated along the Pipestone River and appear to be juxtaposed against rocks of the Central Domain along an east-northeast trending fault which merges with a mylonite zone located on the south side of the granodiorite stock on the east end of Kecheokagan Lake. This mylonite zone is considered to be part of the Kecheokagan Lake Fault Zone which extends east to form the south boundary of the Southern Domain (Figure 8).

Within the Southern Domain, the metasedimentary strata grade southward into paragneisses which are abruptly truncated by the Kecheokagan Lake Fault Zone. Near the fault zone, the paragneisses developed lineations plunging 30± to 60± eastward. Across the fault, they are juxtaposed against gneissic anatectites of mixed protolith.

A wedge of paragneiss occurs south of the anatextic gneisses approximately 0.6 km south of the Kecheokagan Lake Fault Zone. It is not certain if these paragneisses were once part of the Southern Domain. Alternatively these rocks are of a metasedimentary protolith originally associated with the

tholeiitic mafic metavolcanic protolith of the mafic metavolcanic protolith of the mafic to intermediate gneisses south of this paragneiss. Many of these gneisses are augen gneisses with evidence of mylonitization to suggest strong deformation.

Central Domain

In the Central Domain, the metavolcano-sedimentary succession is isoclinally folded about a large anticline (Figure 8). The axis of this anticline extends from the east end of Kecheokagan Lake east-northeast towards the southeast arm of Horseshoe Lake. The anticline plunges steeply northeastward and the metasedimentary rocks located at the nose of fold dip 70± to 90± to the north-northwest based on the attitudes of the rocks located on the limbs of the fold (Figure 9). On the northwest limb of the anticline, north of Kecheokagan Lake, the strata face north and dip 80± to 90± to the north as a homocline. South of the fold axis, east of Kecheokagan Lake along the Pipestone River, the strata are overturned with dips as low as 40± to the north-northwest (Photo 16).

A planar fabric occurs in the less competent metasedimentary rocks subparallel to bedding. This platy fabric is caused by the alignment of chlorite, actinolite, biotitic and muscovite which produces a weak schistosity in the rocks. This schistosity remains subparallel to bedding through the nose of the anticline and in the larger parasitic folds on both sides of the main fold axis to indicate its development in the strata prior to the isoclinal folding. The intersections of this early schistosity

and the cleavage associated with the folding form northeasterly striking variously plunging lineations. The cleavages, and hence the lineations, are refracted across beds of different composition.

The isoclinal folding represented by the anticlinal may represent one of a set of east-northeast trending folds in the Central Domain. A complementary syncline, east of the anticline, described above, may occur south of Wapamisk Creek (Figure 8). The syncline is defined by limited exposure south of Wapamisk Creek that contains north-facing pillows within tholeiitic metavolcanic rock.

East-northeast trending, cross-cutting faults in the hinge zone of the anticline, some of which appear to be reverse faults, cause parts of the southeast limb sequence to be repeated (Figure 9). These brittle faults, as well as several northeast trending faults cross-cutting the northwestern limb of the anticline interested schistosity and cleavage and cause polygonal fractures within the fault zones. Most of the northeast trending faults on the northwest limb of the anticline extend southwest into the mafic to intermediate gneisses of tholeiitic metavolcanic protolith along the north shore of Kecheokagan Lake. The contact between the mafic and intermediate gneisses and the tholeiitic metavolcanic rocks is a relatively undeformed transitional contact.

Northern Domain

The Northern Domain is a long, narrow zone bordered to the north by the Northern Boundary Fault Zone and to the south by the North Horseshoe Lake Fault Zone (Figure 8). The strata of the Northern Domain face south and dip steeply to the south in a direction opposite to the dip of the strata of the Central Domain. The rocks of the Northern Domain, like those of the Central Domain, in particular the fine-grained metasedimentary rocks have a schistosity caused by the alignment of biotite, muscovite and amphibole subparallel to bedding. This schistosity disappears where the rocks reach amphibolite grade metamorphism (Figure 7).

In addition to the mineral schistosity, the rocks have fracture cleavages which intersects the mineral schistosity and produce lineations. The lineations plunge 60± to 70± westward subparallel to the strike of the bedding. Parasitic folds related to the fracture cleavages, were not observed.

In the northwest part of the Horseshoe Lake Greenstone Belt, the Northern and Central Domains are in contact with each other. In this area, the two domains consists of similar rock-types and have undergone amphibolite grade metamorphism. Here and further west in the paragneisses south of the North Boundary Fault Zone near Sasiginaga Lake, the location of the boundary between the Northern and Central Domains becomes uncertain (Figure 8). Extensions of neither the Northern or Southern Horseshoe Lake Fault Zones could be recognized in this area. Instead multiple, narrow zones of brittle deformation and aerial photograph

lineaments occur near the projected contact between the two domains. These fault zones appear to converge with one another eastward and merge with the Northern and Southern Horseshoe Lake Fault Zones which envelope the Calc-alkalic Domain (Figure 8).

On the northside of the Northern Domain, along the North Boundary Fault Zone, the rocks are strongly deformed. The deformation consists of flattening and stretching of mineral and lithic clasts in the metasedimentary rocks and the dislocation of bedding planes. In the fault zone, the metaquartz arenites are mylonitic and the less competent metawackes and metavolcanics become strongly schistose. Paragneiss occurs on the northside of the North Boundary Fault Zone. Westward as the greenschist metamorphic rank sedimentary rocks grade into amphibolite metamorphic rank paragneiss, the North Boundary Fault Zone grades into a broad zone of augen gneiss clearly recognizable within the paragneisses.

Calc-alkalic Domain

In the Calc-alkalic Domain, the strata are folded about a broad syncline whose west-northwest-trending axis is located toward the east end of Horseshoe Lake (Figure 8). The axis of the syncline as defined by pillow facings and graded tuff beds. At its west-northwest end, the axis is truncated by easterly trending orthogneiss located on the northside of the calc-alkalic metavolcanics south of the Northern Horseshoe Lake Fault. At its east-southeast end it is truncated by the Southern Horseshoe Lake Fault Zone on the south side of the Calc-alkalic Domain.

All the calc-alkalic metavolcanics west of the synclinal axis face north to north-northeast and dip steeply northward and thus are part of the southern limb of the syncline (Figure 8). East of Horseshoe Lake structural information is very limited and little is known concerning the thickness and structure of the northern limb of the syncline. Additional megascopic folds are possibly present in this poorly exposed portion of the Calc-alkalic Domain.

In the well exposed southern limb, the strata in the central parts of the Calc-alkalic Domain are less deformed relative to these of the other geological domains. Pillows are undeformed and mineral schistosities and cleavage fracturing are absent to weakly developed. Deformation is mainly restricted to the north and south margins of the Calc-alkalic rocks and to some internal narrow fault zones. Where the rocks intersect the Northern and Southern Horseshoe Lake Fault Zones they become highly schistose. Where the Northern Horseshoe Lake Fault Zone extends into the external gneisses, the metavolcanic rocks in contact with the orthogneisses east of the fault zone display flattening and stretching subparallel to their contact with the gneisses. Along the Southern Horseshoe Lake Fault zone, the angle between the strike of the rocks and the direction of schistosity ranges from 5° to 20°. In the bedded tuffs, the intersection of the bedding planes and the schistosity plunges steeply eastward along the subvertical planes of schistosity (Photo 18). Pillows are stretched several times their width in a steep easterly direction and on horizontal exposures suggest dextral sense of shearing.

Along the western part of the Northern Horseshoe Lake Fault Zone, the schistosity of the calc-alkalic metavolcanic rocks dip 70° to 85° northward. Mineral lineations plunge 60° to 80°± northeast. In cross-section, the fault zone contains Z-shaped, 40° to 60° northeast plunging kink folds. Sense of movement is north side up with a dextral sense of movement. Farther east along the fault zone in the gneisses, the augen structures plunge 40o to 60° northeast.

Discussion

Structural features recognizable within the Horseshoe Lake map area show a complex history of tectonism. The information available is based on one field season only and does not allow a rigorous interpretation of the tectonic events that affected the greenstone belt and its external gneisses and granitoid rocks. A general interpretation, however, is provided in the following..

There is good evidence for multiphase tectonism within each domain of the belt with the exception of the Calc-alkalic Domain. Low angle disconformities within the sequences, in particular the Central Domain, may indicate first phase syndepositional tectonism Schistosities transected by fracture cleavages are suggestive of subsequent events that occurred syndepositionally during basin subsidence or post depositionally during large scale tectonism that folded and disrupted the primary greenstone belt assembalges. The Northern and Southern Domains for example, originally may have formed one depositional basin. The other domains may consist of rock sequences that were deposited in

areas distant from where the rocks of the Northern and Central Domains were deposited. Extensive deformation zones at the boundaries of the domains are suggestive of faults repeatedly activated during large scale tectonic events from the time of the deposition of the rocks of the greenstone belt until the emplacement of the late granitoid rocks. Early dislocation of the metasedimentary-tholeiitic metavolcanic assemblage may have allowed two separate domains, the Northern and Central Domain, to form and separately, undergo additional folding of distinctive styles. Further faulting was probably responsible for the juxtapositioning of the domains against each other and the truncation of most of their structural features including the broad folding within the Calc-alkalic Domain.

The rocks of the Calc-alkalic Domain have escaped strong deformation. This may be either due to deposition that post-dated the main deformation of the other domains - the rocks of this domain therefore would be younger than those of the other domains, - or to deposition of the Calc-alkalic Domain in an area which escaped much tectonism.

The information available on the regional tectonism of the areas underlain by gneisses and granitoid rocks external to the greenstone belt is rather limited. No gneissic rocks occurs within the greenstone belt itself and the contacts of the supracrustal rocks with the gneisses show no major offsets at the major fault zones that are the boundaries of the domains. This observation suggests that the various domains of the greenstone belt had been juxtapositioned against each other prior to or

simultaneously with the deformational event responsible for the formation of the gneisses. At gradational contacts of the greenstone with the external gneisses, however, the gneisses obliquely truncate the earliest deformational structures of the supracrustal rocks. This is an indication that the early deformation events responsible for the structures within and outside the greenstone belt proper are not related and that the early deformation of the greenstones predates the formation of the gneisses. All the rocks (supracrustal and gneissic rocks) of the study area, however, were subjected to a late tectonic event as the major fault zones extend from within the greenstone belt into the gneissic terrains. In the south part of the greenstone belt, the major deformation zones which include the Kecheokagan Lake Fault Zone, extend into zones of blastomylonitic augen gneiss within the gneisses. This observation would indicate the major deformation zones along the domain boundaries remained active during emplacement of the late K-rich, granitoid rocks.

ECONOMIC GEOLOGY

Introduction

Mineralization was first indicated in the Horseshoe Lake Area by Carruthers (1961). This author did not describe the mineralization in any detail. It is possible that prospecting was done in the area as early as the 1920s based on reported discoveries of gold mineralization near Pickle Lake to the south and Windigo Lake to the northwest (Satterly, 1941, Sage and Breaks, 1982). The discovery of some overgrown pits and trenches by field party personnel suggest that some early prospecting was carried out prior to the 1950's.

The first assessment files on the area submitted to Ontario Government Offices date back to 1965 and were submitted by Rio Tinto Canadian Exploration Limited. Since that time exploration has intensified in particular for gold mineralization. Price increases for gold since the 1970s and the recent discovery of commercial gold deposits in the Opapimiskan Lake Area (Breaks et al., 1986) has accelerated gold exploration in the area.

Numerous anomalous gold anomalies have been reported from throughout the Horseshoe Lake Greenstone Belt but none so far are very encouraging. Many occur with anomalous concentrations of copper, zinc and arsenic in association with pyrite and pyrrhotite. The best of the reported gold values are shown in Table 7. They are mainly derived from reports in the Assessment Files Research Office, Ontario Geological Survey, Toronto.

Table 7 is a listing of the exploration work by mining companies in the Horseshoe Lake area and the location of the work of these companies is shown in Figure 12. Twenty blocks of claims have been examined by eight companies in the Kecheokagan Lake and Wapamisk Creek claim-map areas within the administrative district of Sioux Lookout, Ontario. The work reported by these companies mainly consisted of geophysical surveys followed up by diamond drilling and the excavation of some pits and trenches. The work is listed in Table 7 according to the company and year. For more detailed information, the reader is referred to the Resident Geologists Files, Ministry of Northern and Mines, Sioux Lookout, Ontario or the Assessment Files Research Office, Ontario Geological Survey, Toronto, Ontario.

Gold geochemical analyses were done by the Geoscience Laboratories, Ontario Geological Survey, on 87 gossan samples, collected by field crew personnel, 16 of which contained >10 ppb Au. The locations of these anomalous samples are shown on the map according to their range of values as indicated in the legend.

Mineralization and Exploration

Mineralization in the Horseshoe Lake Greenstone Belt is largely located in the Central and Calc-alkalic Domains and is distinctive in the two domains. In the Central Domain, gold mineralization tends to be concentrated in narrow, pyritiferous east-northeast trending shear zones, particularly near the nose of the anticline in the vicinity of north cross-cutting late

perthite and quartz-perthite-phyric dikes. Much of the work done by Dome Exploration (Canada) Limited (3) and Rio Tinto Canadian Exploration (20) is focused here. Both the companies and the author obtained anomalous values from shear zones, from the porphyry and from contact zones between the porphyry and the host tholeiitic metabasalts and metasediments. Some mineralization is associated with narrow quartz-carbonate veins and is similar to the mineralization farther south on the property of 581356 Ontario Limited (16) that was examined earlier by Dome Exploration (Canada) Limited (2). The property of 581356 Ontario Limited (16) is also cut by the same perthite and quartz-perthite porphyry dikes that extend north to Horseshoe Lake. Much of the area between property 16 and property 3 contains dikes of perthite and quartz-perthite porphyry as do gneissic areas farther south. These areas warrant further examination.

No anomalous values of gold were obtained from the sulphide-bearing gneisses and iron-formations near the north shore of Kecheokagan Lake by Great Plains Development Company of Canada Limited (7 and 8) and by the author. The author did obtain anomalous values along and near some late, north-east trending shear zones north of areas explored by Great Plains Development Company of Canada Limited. These areas are indicated on the map (Back Pocket) and are yet to be explored. Intersections of these fau'lt zone with the iron formation north of Kecheokagan Lake may offer exploration targets.

Gossan surfaced pebbly wackes with vein-quartz and sulphide pebbles in the Central Domain have low anomalous gold values.

These rocks were recognized in several localities in the metavolcano-sedimentary succession over a 10 km distance in the north part of the Central Domain and were tested for their gold content at 3 widely-space locations by the author. Two of the locations occur at Horseshoe Lake and the third occurs 4 km farther west. Gold may be primary or secondary. Direction of transport for the clasts was probably from the west to southwest and should be considered during further exploration either for syngenetic or epigenetic gold mineralization. The intersection of pyrite-rich pebbly wacke and north-east trending fractures are possible locii for gold concentration.

In the Calc-alkalic Domain, mineralization consists of massive to disseminated stratigraphy controlled pyrite and pyrrhotite in association with graphitic mudstone, banded iron formation, and chert that are interlayered with calc-alkalic metavolcanic tuffs. This sulphide mineralization readily produces geophysical anomalies which have be the focus of attention by Canadian Occidental Petroleum Limited (1), Great Plains Developed Company of Canada (6 and 9), Norcen Energy Resources Limited (15), Petromet Resources Limited (17), Greenstrike Gold Corporation (11, 12, and 13) and Rio Tinto Canadian Exploration Limited (18) (Table 7). In general the results of the exploration efforts by these companies have not been encouraging although some anomalous gold and basemetal values have been obtained (Table 7).

RECOMMENDATION FOR FUTURE EXPLORATION

In the Calc-alkalic domain, the grade bedding and finesses of the pyroclastic rocks and their close association with iron formation and carbonaceous mudstone suggest these rocks were deposited subaqueously on the distal flanks of calc-alkalic volcanic centers, and possibly have a gold 'facies'. Consideration should be given to looking for off-sets in the geophysical anomalies which may indicate intersections of faults and sulphide horizons where gold mineralization may have formed by replacement. Similar target zones would also occur in shear zones along the boundaries between the Calc-alkalic Domain and the Central and Northern Domains as well as the contact between the intermediate and felsic orthogneisses and the paragneisses farther north. Geophysical anomalies caused by sulphide mineralization within the intermediate to felsic gneiss have been found and investigated by Great Plains Development of Canada Limited (9).

To the author's knowledge no investigation has been made of the major fault zones located at boundaries of the domains nor those located in the gneisses. The intersection of the fault zones with north-east and east-northeast trending fault zones, as well as zones of sulphide mineralization and iron-formation offer target opportunities.

No anomalous gold values were found in the mylonite zone located on the south side of the granodiorite stock at the east end of Kecheokagan Lake. The granodiorite stock predates the mylonite zone but the stock and its contacts with the metavolcanic and metasedimentary rocks have yet to be examined.

The paragneisses and orthogneisses external to the Horseshoe Lake Greenstone Belt have been left unexplored. Further work should be carried out to examine the extend the various lithological units identified during the present mapping project. Remnants of supracrustal rocks may carry mineralization. Some sulphide mineralization occurs in the iron formation zone within the tholeiitic metabasalts along the South Pipestone River southwest of Kecheokagan Lake and represents a target for gold exploration. The pegmatite rocks in the batholith south of the belt have not been examined for their potential rare-element content and the paragneisses to the north are unknown.

Recommendations

In summary targets for further exploration for gold mineralization are listed as follows:

1) late northeast- to east-northeast-trending shear zones in the Central Domain
2) late K-rich feldspar and quartz-K-feldspar porphyry dikes
3) shear zones along domain boundaries
4) units of sulphide-bearing metasedimentary rocks
5) sulphide-rich units of iron formation (see Hall and Rigg, 1986).

Explorationists should focus their attention to areas where these features intersect one another. The author also believes that locations where these features are intersected by the anticlinal axial zone in the Central Domain should be explored. The pegmatite rocks in the batholith south of the belt have not

been examined for their potential rare-element content and the paragneisses to the north are unknown. Reconnaissance geophysical and geological surveys should be carried out on the external granitoid rocks for structure, supracrustal remnants, and complex pegmatites which might contain economic mineral concentrations.

REFERENCES

Breaks, F.W., Bartlett, J.R., Osmani, I.A., Finamore, P.F., and Wallace, H.

1985: Opapimiskan Lake Project: Precambrian and Quaternary Geology of the North Caribou Lake Area, District of Kenora, Patricia Portion; p.268-276 in Summary of Field Work 1985, Ontario Geological Survey, edited by John Wood, Owen L. White, R.B. Barlow, and A.C. Colvine, Ontario Geological Survey, Miscellaneous Paper 126, 351p.

Breaks, F.W., Osmani, I.A. and De Kemp, E.A.

1986: Opapimiskan Lake Project: Precambrian Geology of the Opapimiskan-Forester Lakes Area, District of Kenora, Patricia Portion; p.368-378 in Summary of Field Work and other Activities 1986, by the Ontario Geological Survey, edited by P.C. Thurston, Owen L. White, R.B. Barlow, M.E. Cherry and A.C. Colvine, Ontario Geological Survey, Miscellaneous Paper 132, 435p. Accompanied by 1 Chart.

Carruthers, C.A.

1961: Geology, North Caribou Lake, Ontario; Geological Survey of Canada, map 18-1961, scale 1 inch to 4 miles.

Finamore, P.F., an Carswell, B.F.

1986: Quaternary Geology of the Mawley Lake-Forester Lake Area. District of Kenora (Patricia Portion); Ontario Geological Survey, Map P.3045, Geological Series-Preliminary Map, scale 1:50 000. Geology 1985.

Hall, R.S., and Rigg, D.M.

1986: Geology of the West Anticline Zone, Musselwhite Prospect, Opapimiskan Lake, Ontario, Canada; p.124-136 in Proceedings of Gold'86, an International Symposium on the Geology of Gold: Toronto, 1986, edited by A.J. Macdonald, 517p.

Howe, J.M., Easton, R.M., Grunsky, E.C., Jensen, L.S., and Thurston, P.C.

1987: Komatiite Database, Parts I and II; Ontario Geological Survey, Open File Report 5677, Part I, 202p., 12 tables; Part II, 3 ASCII disks or 4 DIF disks, in back pocket.

Jensen, L.S.

1976: A new Cation Plot for Classifying Subalkalic Rocks: Ontario Division of Mines, Miscellaneous paper 66, 22p.

1987: Geology of the Horseshoe Lake Greenstone Belt, District of Kenora, p.104-108 in Summary of Field Work and Other Activities, 1987, by the Ontario Geological Survey, edited by R.B. Barlow, M.E. Cherry, A.C. Colvine, B.O. Dressler and O.L. White. Ontario Geological Survey, Miscellaneous Paper 137, 429p.

1988a: Horseshoe Lake Area (East Half), District of Kenora; Ontario Geological Survey, Map P. , Geological Series

- Preliminary Map, Scale 1:15 840 or 1 inch to 1/4 mile. Geology 1987.

1988b: Horseshoe Lake (West half), District of Kenora; Ontario Geological Survey, Map P. , Geological Series - Preliminary Map, Scale 1:15 840 or 1 inch to 1/4 mile. Geology 1987.

Jensen, L.S., and Langford, F.F.

1985: Geology and Petrogenesis of the Archean Abitibi Belt in the Kirkland Lake Area, Ontario; Ontario Geological Survey, Miscellaneous Paper 123, 130p. Accompanied by Maps P.2434 and P.2435, scale 1:63 360 or 1 inch to 1 mile and sheet of microfiche.

Mehnert, K.R.

1968: Migmatites and the Origin of Granitic Rocks; Elsevier Publishing Company, New York, 393p.

Mollard, J.D. and Janes, J. Robert

1984: Airphoto Interpretation and the Canadian Landscape; Energy, Mines and Resources Canada, Canadian Government Publishing Centre, Hull, Quebec, Canada, 415p.

ODM-GSC

1960: Kecheokagan Lake, Kenora District, Ontario; Ontario Department of Mines - Geological Survey of Canada, Aeromagnetic Series, Map 916G. Scale 1:63 360.

Prest, V.K.

1963: Red Lake-Lansdowne House Area, Northwestern Ontario; Geological Survey of Canada, Paper 63-6, 21p.

Sage, R.P., and Breaks, F.W.

1982: Geology of the Cat Lake-Pickle Lake Area, Districts of Kenora and Thunder Bay; Ontario Geological Survey, Geological Report 207, 238p. Accompanied by Map 2218, scale 1:253 440 or 1 inch to 4 miles.

Satterly, J.

1941: Geology of the Windigo-North Caribou Lakes Area, Kenora District; Ontario Department of Mines, Annual Report for 1939, Volume 48, Part 9. Accompanied by Map 48j, scale 1 inch to 2 miles.

Streckeisen, A.

1976: To each plutonic rock its proper name; Earth-Science Reviews, Volume 12, p.1-33.

Tchalenko, J.S.

1970: Similarities between Shear Zones of Different Magnitudes; Geological Society America Bulletin, V.81, p.1625-1640.

Thurston, P.C., Cortis, A.L., and Chivers, K.M.

1987: A Reconnaissance Re-evaluation of a Number of Northwestern Greenstone Belts: Evidence for an Early Archean Crust: p.4-24 in Summary of Field Work and Other Activities 1987; by the Ontario Geological Survey, edited by R.B. Barlow, M.E. Cherry, A.C. Colvine, Burkhard O. Dressler, and Owen L. White, Ontario Geological Survey, Miscellaneous Paper 137, 429p.

Winkler, H.G.F.

1967: Petrogenesis of Metamorphic Rocks; Springer-Verlag, New York Inc., New York, 237p.

Table 1: Table of Lithologic Units For the Horseshoe Lake Area

PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT
Swamp, bog, lake and stream deposits
PLEISTOCENE
Glacial and fluvialglacial till, sand and gravel deposits

Unconformity

PRECAMBRIAN
ARCHEAN
MIDDLE TO LATE ARCHEAN
LATE MAFIC INTRUSIVE ROCKS
Lamprophyre, diabase

Intrusive Contact
EXTERNAL GRANITOID ROCKS
LATE GNEISSIC TO MASSIVE GRANITOID ROCKS
Granodiorite, monzogranite, syenogranite, pegmatite, and perthite- and quartz-perthite-phyric dikes

Intrusive Contact
EARLY GNEISSIC GRANITOID ROCKS
Trondhjemite, tonalite quartz-diorite and pegmatite Intrusive, gradational and faulted contacts
GNEISSIC ROCKS ANATECTITES
Mesocratic to leucocratic, biotite-to hornblende-quartz-feldspar gneiss

Faulted and Gradational Contacts
INTERMEDIATE TO FELSIC ORTHOGNEISSES
Mesocratic to leucocratic hornblende-quartz-feldspar gneiss and quartz-hornblende-feldspar gneiss

Faulted and gradational Contacts
MAFIC TO INTERMEDIATE ORTHOGNEISSES
Melanocratic to leucocratic hornblende-quartz-feldspar gneiss and quartz-hornblende-feldspar gneiss

Faulted and gradational Contacts
PARAGNEISSES
Leucocratic to mesocratic, muscovite and biotite-quartz-feldspar gneiss

Gradational Contacts
INTERNAL INTRUSIVE ROCKS
FELSIC INTRUSIVE ROCKS
Trondhjemite and plagioclase quartz-plagioclase-phyric dikes

Intrusive Contact

MAFIC INTRUSIVE ROCKS

Fine-grained mafic dikes

Intrusive Contact

MAFIC TO INTERMEDIATE INTRUSIVE ROCKS

Gabbro, anorthositic gabbro, diorite

Intrusive Contact

METAVOLCANIC ROCKS

CALC-ALKALIC INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS

Dacite and rhyolite tuff and crystal tuff

CALC-ALKALIC MAFIC TO INTERMEDIATE METAVOLCANIC ROCKS

Basalt and andesite massive and pillowed flows, tuff, crystal tuff and tuff breccia

Faulted Contact

THOLEIITIC INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS

Dacite and Rhyolite tuff

THOLEIITIC IRON-RICH MAFIC TO INTERMEDIATE METAVOLCANIC ROCKS

Basalt and andesite, massive and pillowed flows

THOLEIITIC MAGNESIUM-RICH MAFIC METAVOLCANIC ROCKS

Massive and pillowed basalt flows

METASEDIMENTARY ROCKS

CLASTIC AND CHEMICAL SEDIMENTARY ROCKS

Conglomerate, wacke, arenite, siltstone, mudstone, chert, Iron-formation, limestone, graphitic mudstone, fuchsitic siltstone and magnetite-bearing arenite

Table 2: Chemical analysis of thick-unit metasedimentary rocks

MAJOR OXIDE PERCENT	S1 87LSJ -1424	S2 87LSJ -0862	S3 87LSJ 0962	S4 87LSJ -0747	S5 87LSJ -835	BA RH7 -50
SiO2	59.70	66.40	66.80	68.80	71.30	64.00
Al2O3	16.20	16.00	14.50	16.10	14.70	.63
Fe2O3	2.58	0.99	0.74	0.20	0.33	2.51
FeO	3.39	2.13	6.52	0.67	1.20	4.28
MnO	0.09	0.05	0.08	0.01	0.05	4.68
MgO	4.04	1.63	2.67	3.12	0.27	3.60
CaO	6.25	3.68	0.38	0.93	1.64	2.27
Na2O	3.82	4.46	0.39	4.87	4.24	0.44
K2O	0.91	1.80	2.66	1.52	3.95	0.06
P2O5	0.20	0.11	0.06	0.08	0.05	0.15
CO2	0.63	0.74	0.10	0.10	0.14	2.15
S	0.04	0.01	0.09	0.01	0.01	0.08
H2O+	1.20	0.81	3.60	1.85	0.71	1.22
H2O-	00.00	0.08	00.00	00.00	00.00	0.14
LOI	1.40	1.30	3.60	1.80	0.50	-
TOTAL	99.50	99.20	99.30	98.70	98.80	101.03
S.G.	2.80	2.76	2.82	2.67	2.68	-
TRACE ELEMENTS IN PPM						
Co	20	11	20	5	5	10
Cr	107	41	185	63	12	70
Cu	34	10	19	6	6	20
Ni	45	17	122	41	-5	25
Pb	18	46	24	22	32	25
Zn	86	55	99	-10	40	55
Nb -	5	-5	-5	5	5	-
Rb	21	60	64	31	142	-
Sr	788	615	59	156	237	300
Y	16	8	8	15	10	20
Zr	149	137	201	187	147	150
Th	16	1	10	16	19	-

S1 Grey, 1 mm grainedmetasiltstone
S2 Grey 2-3 mm grained metawacke
S3 Bedded, grey, 1 to 2 mm meta-arenite
S4 Cherty, aphanitic, light grey, metamudstone at top of metasedimentary unit
S5 Light grey, siltstone
BA Light grey 2 mm grained meta-arenite (Dacite, from Sage and Breaks, 1982)

Table 3: Chemical analyses of interflow and magnetite bearing metasedimentary rocks and impure limestone

MAJOR OXIDE PERCENT	S6 87LSJ -0937	S7 87LSJ -0998	S8 87LSJ -0881	S9 87LSJ -0833	S10 87LSJ -0813	S11 87LSJ -0927	S12 87LSJ -0834	S13 87LSJ -0979
SiO2	56.80	60.50	66.60	59.60	62.00	64.30	64.50	27.10
Al2O3	15.70	16.20	16.70	12.10	11.70	11.50	11.90	12.40
Fe2O3	2.26	0.90	0.94	7.69	5.69	5.37	4.69	00.00
FeO	3.59	4.13	1.53	8.92	7.12	6.06	7.12	4.33
MnO	0.10	0.09	0.04	0.15	0.23	0.16	0.17	0.11
MgO	5.11	2.15	1.05	0.93	0.58	0.59	0.99	2.48
CaO	6.98	5.15	3.57	2.87	3.66	4.63	2.97	26.40
Na2O	4.61	4.32	4.28	4.32	5.66	4.65	5.20	1.47
K2O	0.55	2.12	2.62	0.09	0.32	0.31	0.24	2.00
P2O5	0.40	0.16	0.07	0.36	0.26	0.16	0.17	0.05
CO2	0.42	1.97	1.23	0.10	0.27	0.14	0.26	20.10
S	0.03	0.07	0.01	0.05	0.02	0.01	0.02	0.03
H2O+	1.37	0.98	0.85	0.54	0.74	0.62	0.81	1.14
H2O-	00.00	00.00	00.00	00.00	0.09	00.00	00.00	00.00
LOI	1.10	2.30	1.70	0.50	0.10	00.00	0.30	20.80
TOTAL	98.50	99.30	99.80	98.70	99.30	99.30	99.80	98.40
S.G.	2.86	2.75	2.72	2.93	2.87	2.88	2.87	2.80
TRACE ELEMENTS IN PPM								
Co	20	13	8	14	5	5	6	20
Cr	168	11	22	11	11	-10	-10	221
Cu	24	39	16	17	7	7	6	18
Ni	112	6	11	-5	-5	-5	-5	49
Pb	14	-10	14	36	-10	20	-10	-10
Zn	84	48	43	80	71	62	62	31
Nb	-5	-5	-5	17	22	19	20	-5
Rb	12	49	81	-5	-5	-5	-5	37
Sr	909	123	3 47	56	55	74	75	131
Y	18	13	6	136	145	126	115	64
Zr	177	135	137	535	441	429	408	69
Th	27	15	-10	11	12	-10	-10	-10

S6 Darkgreen, 0.5 mm grained, micaceous, interflow metasiltstone
S7 Grey, fine grained interflow metasiltstone
S8 Bluish grey, quartz-rich micaceous interflow metawacke
S9 Darkgrey, 1 mm grained, massive, magnetic meta-arenite
S10 Grey, 1 mm grained, massive, magnetic metawacke
S11 Black, 1 mm grained, massive, magnetic metawacke
S12 Grey 1 mm grained, massive, magnetic meta-arenite
S13 Darkgrey, schistose, 0.5 mm grained metalimestone

Table 4: Chemical analysis of tholeiitic metavolcanic Rock

MAJOR OXIDE PERCENT	T1 87LSJ -0947	T2 87LSJ -0915	T3 87LSJ -0818	T4 87LSJ -0720	T5 87LSJ -0987	T6 87LSJ -0975	T7 87LSJ -0985	T8 87LSJ -0885	T9 87LSJ -0876
SiO2	47.50	47.80	48.10	49.50	48.40	49.50	46.40	50.30	49.30
Al2O3	14.30	15.30	16.50	15.30	15.10	17.00	14.10	14.40	13.70
Fe2O3	1.80	2.90	2.59	3.56	2.93	2.40	2.10	6.42	2.30
FeO	10.20	9.32	8.65	8.05	8.98	8.19	9.12	6.19	11.80
MnO	0.14	0.20	0.17	0.20	0.15	0.18	0.14	0.14	0.23
MgO	8.51	8.25	6.33	6.14	6.49	5.66	5.05	5.59	6.59
CaO	7.82	11.20	11.60	9.66	7.96	10.60	9.82	8.94	9.26
Na2O	1.34	2.19	2.25	1.70	2.51	2.39	2.31	3.38	2.11
K2O	0.15	0.23	0.24	0.15	0.10	0.15	0.45	0.40	0.21
P2O5	0.07	0.05	0.09	0.06	0.06	0.04	0.09	0.05	0.08
CO2	2.90	0.09	0.09	1.49	3.33	0.57	5.98	0.54	0.12
S	0.01	0.06	0.06	0.05	0.01	0.05	0.01	0.04	0.05
H2O+	4.37	1.36	1.28	3.26	3.22	1.94	3.52	1.25	1.65
H2O-	0.12	00.00	00.00	00.00	0.04	00.00	00.00	0.08	00.00
LOI	6.40	0.60	0.50	3.90	5.70	2.10	8.80	1.00	0.50
TOTAL	100.00	99.80	99.00	99.90	100.00	99.30	99.80	98.40	98.70
S.G.	2.88	3.07	3.04	2.97	2.86	2.98	2.83	2.97	3.10
TRACE ELEMENTS IN PPM									
Co	48	50	42	39	37	40	33	32	39
Cr	274	110	406	86	35	59	22	46	203
Cu	49	103	42	102	10	113	12	235	115
Ni	76	124	119	52	31	41	31	39	53
Pb	-10	-10	-10	16	-10	16	-10	25	26
Zn	53	113	81	117	42	74	52	57	111
Nb	-5	-5	-5	-5	-5	-5	-5	-5	-5
Rb	-5	-5	-5	-5	-5	-5	8	-5	-5
Sr	166	201	151	117	168	135	153	200	133
Y	22	21	27	30	26	19	24	20	38
Zr	82	78	99	72	77	68	81	66	103
Th	-10	-10	-10	-10	-10	-10	-10	10	-10

1. Report and map re serence number
2. Field sample number

T1 Carbonated schistose Mg-rich tholeiitic basalt
T2 Schistose Mg-rich tholeiitic basalt
T3 Gabbroic textured Mg-rich tholeiitic basalt
T4 Fine grained, Mg-rich tholeiitic basalt
T5 Carbonatized, schistose, weakly magnetic, blue quartz-bearing Fe-rich tholeiitic basalt
T6 Plagioclase-rich, tholeiitic basalt
T7 Carbonatized, schistose, magnetic Fe-rich tholeiitic basalt
T8 Diabasic textured, magnetic Fe-rich theoleiitic basalt
T9 Diabasic textured, magnetic Fe-rich theoleiitic basalt

Table 4: Cont'd.....

MAJOR OXIDE PERCENT	T10 87LSJ -0932	T11 87LSJ -0793	T12 87LSJ -01434	T13 87LSJ -0860	T14 87LSJ - 01513	AZ 87LSJ -29	BB 87LSJ -74	BC 87LSJ -10
SiO2	54.60	50.90	48.90	48.20	51.20	50.00	48.01	51.00
Al2O3	12.00	12.20	11.90	12.10	16.60	14.04	15.05	12.05
Fe2O3	4.80	5.50	9.10	12.50	2.10	2.28	2.30	5.31
FeO	9.05	11.70	11.80	8.12	9.32	8.20	8.45	6.55
MnO	0.13	0.18	0.25	0.21	3.71	7.34	7.46	9.85
MgO	2.76	4.16	4.65	3.50	11.50	10.20	11.20	11.30
CaO	4.84	4.21	5.49	6.33	2.07	2.94	2.67	1.74
Na2O	4.20	3.17	3.15	4.04	0.12	0.16	0.33	0.15
K2O	0.06	0.07	0.12	0.26	0.93	0.05	1.24	0.64
P2O5	0.11	0.18	0.11	0.10	0.07	0.13	0.10	0.06
CO2	3.48	3.07	0.33	0.81	0.46	0.35	0.18	0.23
S	0.06	0.01	0.01	0.18	0.03	0.13	0.15	0.07
H2O+	2.62	3.29	2.19	0.23	1.79	1.38	1.00	0.91
H2O-	00.00	0.03	0.09	00.00	00.00	0.12	0.14	0.07
LOI	4.90	5.10	1.10	0.40	1.20	ND	ND	ND
TOTAL	100.10	99.90	99.80	98.30	100.00	98.4	99.0	100.06
S.G.	2.92	2.93	3.08	3.11	3.02	ND	ND	ND
TRACE ELEMENTS IN PPM								
Co	19	37	50	37	35	40	45	40
Cr	12	16	-10	28	10	750	440	70
Cu	11	46	21	102	97	140	100	390
Ni	-5	-5	-5	16	30	80	110	50
Pb	-10	-10	-10	61	-10	10	15	10
Zn	33	86	150	111	84	85	80	80
Nb	-5	-5	-5	-5	-5	ND	ND	ND
Rb	-5	-5	-5	-5	-5	ND	ND	ND
Sr	135	91	133	167	91	250	250	150
Y	51	47	50	52	47	30	60	20
Zr	139	102	116	124	02	50	120	40
Th	-10	-10	-10	-10	10	ND	ND	ND

T10 Silver-grey,schistose, carbonated, magnetic, blue-quartz-bearing Fe-rich tholeiitic basa
T11 Carbonated, schistose, magnetic, blue-quartz-bearing, Fe-rich tholeiitic basalt
T12 Schistose, magnetic, blue-quartz bearing Fe-rich tholeiitic basalt
T13 Diabase textured, magnetic Fe-rich tholeiitic basalt
T14 Granophyric tholeiitic andesite
AZ Pyroxene-phyric Mg-rich tholeiitic basalt (Gabbro, from Sage & Breaks,1982)
BB Pyroxene-phyric Mg-rich tholeiitic basalt (Gabbro, from Sage & Breaks,1982)
BC Pyroxene-phyric Mg-rich tholeiitic basalt (Gabbro, from Sage & Breaks,1982)

Table 5: Chemical analyses of calc-alkalic metavolcanic and subvolcanic rocks

	C1	C2	C3	C4	C5	I1	I2	I3
MAJOR	87LSJ	87LSJ	87LSJ	87LSJ	87LSJ	87LSJ	87LSJ	87LSJ
OXIDE	-1392	-1443	0725	-1390	-1382	-1464	-0719	-0718
PERCENT								
SiO2	48.30	48.60	53.10	64.80	63.70	50.20	66.20	66.00
Al2O3	15.30	18.00	16.10	16.10	17.00	1.33	14.90	15.50
Fe2O3	1.87	2.35	3.48	0.54	1.91	7.99	1.21	0.87
FeO	7.59	6.85	5.06	4.13	1.86	12.40	1.93	1.93
MnO	0.15	0.17	0.15	0.07	0.06	10.10	0.06	0.05
MgO	9.10	6.38	4.39	1.50	1.46	1.29	1.23	1.31
CaO	10.80	12.00	6.81	2.09	3.47	0 67	2.78	2.76
Na2O	1.46	1.50	3.65	2.29	4.93	0.36	4.33	3.46
K2O	0.24	0.21	0.20	2.50	1.91	0.01	2.76	2.36
P2O5	0.03	0.04	0.17	0.09	0.15	0.20	0.17	0.10
CO2	0.54	0.36	2.67	1.65	0.55	0.07	2.06	2.09
S	0.14	0.01	0.11	0.01	0.01	0.02	0.15	0.07
H2O+	3.50	2.82	2.73	2.64	1.74	3.22	1.58	2.04
H2O-	0.06	00.00	0.11	0.05	00.00	00.00	00.00	00.00
LOI	3.10	2.40	4.80	3.60	1.90	2.50	3.00	3.50
TOTAL	99.50	99.80	99.40	99.60	99.10	99.60	99.60	98.90
S.G.	3.01	2.99	2.82	2.76	2.76	2.99	2.71	2.73
TRACE ELEMENTS IN PPM								
Co	46	39	31	29	11	48	9	8
Cr	580	97	36	175	11	510	24	34
Cu	116	96	47	82	7	235	18	263
Ni	174	72	20	68	10	203	13	19
Pb	-10	- 10	19	-10	-10	-10	23	12
Zn	77	77	87	61	44	74	63	72
Nb	-5	-5	-5	-5	-5	-5	-5	-5
Rb	-5	5	-5	78	44	33	98	69
Sr	83	103	572	224	442	95	500	199
Y	15	14	16	18	9	9	10	6
Zr	58	57	143	117	131	41	146	132
Th	10	-10	-10	-10	11	-10	24	-10

C1 Light-green, 2 to 3mm grained Mg-rich tholeiitic basalt; note low total FeO
C2 Light-green 1 to 2mm grained calc-alkalic basalt
C3 Green, 0.5-1mm grained calc-alkalic basalt
C4 Lighgreen, massive, fine grained calc-alkalic dacite
C5 Green, schistose, fine grained calc-alkalic dacite
I1 Grey, 3 to 4mm grained gabbro intrusive to calc-alkalic metavolcanic rock
I2 Schistose, augened quartz and plagioclase phenocrysts in quartz-plagioclase phyric
I3 Schistose, fine-grained quartz-plagioclase-phyric dike (calc-alkalic rhyolite)

Table 6: Chemical analysis of mafic dikes

MAJOR OXIDE PERCENT	I4 87LSJ -0842	I5 87LSJ -0858	I6 87LSJ -0949
SiO2	53.90	54.60	53.10
Al2O3	14.00	14.70	15.70
Fe2O3	1.55	2.31	1.28
FeO	7.79	5.86	6.66
MnO	0.15	0.14	0.16
MgO	6.45	6.58	5.88
CaO	8.26	8.44	9.56
Na2O	2.54	2.06	1.29
K2O	0.47	1.04	1.59
P2O5	0.16	0.17	0.29
CO2	0.24	0.75	1.53
S	0.09	0.02	0.42
H2O+	1.70	1.61	1.45
H2O-	00.00	00.00	00.00
LOI	1.00	1.40	1.90
TOTAL	98.60	99.10	99.40
S.G.	2.92	2.90	2.88
TRACE ELEMENTS IN PPM			
Co	35	36	36
Cr	405	396	302
Cu	36	25	64
Ni	163	162	83
Pb	-10	22	10
Zn	111	153	105
Nb	-5	-5	-5
Rb	15	29	56
Sr	363	360	236
Y	18	15	17
Zr	132	136	131
Th	15	-10	-10

I4 Dark green, 1 mm grained mafic dike
I5 Dark grey fine-grained mafic dike
I6 Black, 1 mm grained, pitty weathered surfaced mafic dike

Table 7: Table of Mineral Exploration in the Horseshoe Lake Area

Name of Company/Occurrence	Year	Claim Map Area	Exploration	Assay Reported Mineralization	Geology of Best Mineralization
1. Canadian Occidental Petroleum Limited	1982	Wapamisk Cr.	3 trenches, total length of 34 m, 1 ground magnetic survey of 21 Line km, 1 ground VLF-EM survey of 34.2 Line km	Py, As 0 to 80 ppb Au	pyrite in iron formation with metamudstone, graphite, chert, tuff tuff, tuff-breccia and carbonate
2. Dome Exploration (Canada) Limited South Group	1975 1975 1975 1975 1976	Kecheokagan Lake	geological mapping, geochemical soil survey and a ground magnetic survey over a 4 claim area followed by trenches and 2 ddhs totalling 182.9 m	tr to 26.7 g/t Au; minor Cu, Pb	gold in quartz veinlets parallel to feldspar-phyric dikes cutting mafic metavolcanics and metasediments
3. Dome Exploration (Canada) Limited North Group	1975 1976	Kecheokagan Lake	ground magnetic survey over a 12 claim area followed by 15 ddhs totalling 1957.7 m	tr to 3.1 g/t Au; As, minor Cu	gold in schistose Fe-rich tholeiitic basalt and in feldspar and quartz-phyric dikes
4. Dome Exploration (Canada) Limited	1981	Kecheokagan Lake and Wapamisk Cr.	airborne magnetic survey of 70 lines totalling 210 km		
5. Great Plains Development Company of Canada, Limited	1971	Kecheokagan Lake and Wapamisk Cr.	airborne magnetic and EM surveys over 455 claims		
6. Great Plains Development Company of Canada Ltd. (Area 1)	1972	Kecheokagan Lake	ground EM survey, geological mapping and 7 ddhs totalling 266.7 m	massive Py,Po minor Cu, tr Au	sulphides in schistose calc-alkalic basalt tuffs and narrow iron formation
7. Great Plains Development Company of Canada Limited (PA 311144)	1972	Kecheokagan Lake	ground EM and magnetic surveys, geological mapping and 1 ddh of 31.4 m	disseminated Py, Po; 0.04% Cu; tr Au	sulphides in schistose mafic metasediment (biotite gneiss) and iron formation
8. Great Plains Development Company of Canada Ltd. (PA 311182)	1972	Kecheokagan Lake	ground EM and magnetic surveys, geological mapping and 1 ddh of 40.5 m	veined Py,Po; 0.1% Ni; tr,Au	sulphides in qcv and fractures cutting qtz - hbd - fsp gneiss
9. Great Plains Development Company of Canada Ltd. (Rose Lake B Grid)	1972	Wapamisk Cr.	ground EM and magnetic surveys and 3 ddhs totalling 435.3 m	massive and disseminated Py and Po, tr Cu, tr Zn, tr Ni	sulphides in foliated to gneissic migmatized calc-alkalic basalt tuff, graphitic mudstone and minor iron formation

10. Great Plains Development Company of Canada Ltd. (Rose Lake E Grid)	1972	Wapamisk Cr.	ground EM and magnetic surveys and 1 ddh of 38.4 m	dissiminated Py and Po, 0.05% sp	sulphides in paragneiss
11. Greenstrike Gold Corporation	1985 1986		ground VLF-EM survey and 1 ddh of 133.2 m	0-60 ppb Au; Zn,Cu	qcv in pyritic schistose calc-alkalic metabasalt tuff with IF, graphite
12. Greenstrike Gold Corporation	1985 1986		ground VLF-EM survey and 2 ddhs totalling 269.4 m	0-1000 ppm Cu	
13. Greenstone Gold Corporation	1985 1986		ground VLF-EM survey and 1 ddh of 124.0 m	tr Cu, Zn	
14. Norcen Energy Resources Limited	1981	Kecheokagan Lake	geological mapping, geochemical sampling over 561 claim areas and 67 overburden drill holes	23 ppm Au, 7.8 ppm Ag, 691 ppb Au	quartz vein, soil sample
15. Norcen Energy Resources Limited	1981	Wapamisk Cr.	ground magnetic and EM surveys		
16. 581356 Ontario Limited	1984	Kecheokagan Lake and Wapamisk Cr.	ground magnetic and VLF-EM surveys over 24 claims		see property 2
17. Petromet Resources	1983 1984	Wapamisk Cr.	airborne magnetic and EM surveys over 443 Line km, ground VLF-EM surveys and 31 overburden drill holes	19 conductors	
18. Rio Tinto Canadian Exploration Limited (Sulphide Zone Group)	1962-1965	Kecheokagan Lake	ground magnetic and EM surveys and 1 ddh (length unreported)	massive Py and Po 0.12% Cu, 1.7 g/t Au, 2.0 g/t Ag	7.6 m wide sulphide zone assoc with schistose calc-alkalic metabasalt tuff
19. Rio Tinto Canadian Exploration Limited (Rust Seep Group)	1962	Kecheokagan Lake	ground magnetic and EM surveys		
20. Rio Tinto Canadian Exploration Limited (Shear Zone Group)	1962	Kecheokagan Lake	ground magnetic and EM surveys and 4 ddhs totalling 364.8 m	0.68 g/t Au 6.17 g/t Ag 1.0 g/t Au 1.0 g/t Ag,	Au and Ag in surface 3 m wide NE trending pyritic shear zone in tholeiitic basalt see Property 3 Au and Ag at contact of quartz-perthite-phyric dike cutting

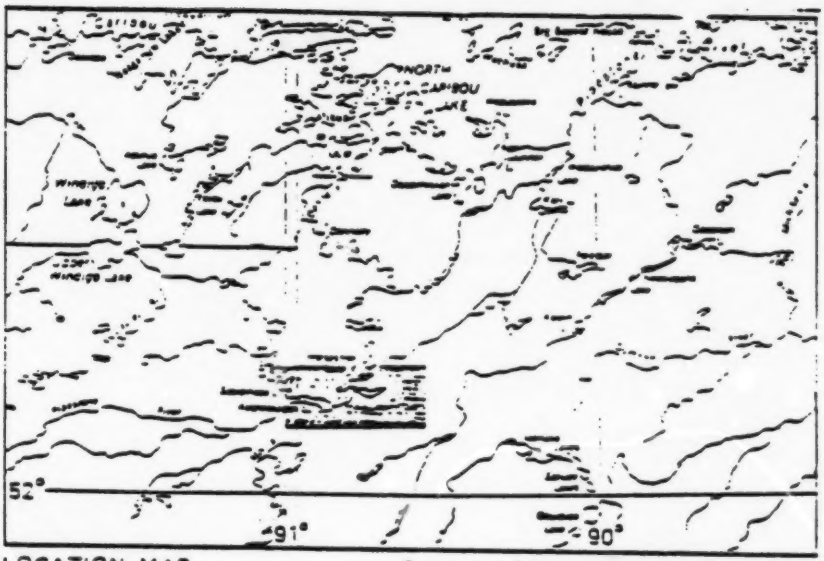


Figure 1: LOCATION MAP Scale: 1:1 584 000 or 1 inch to 25 miles

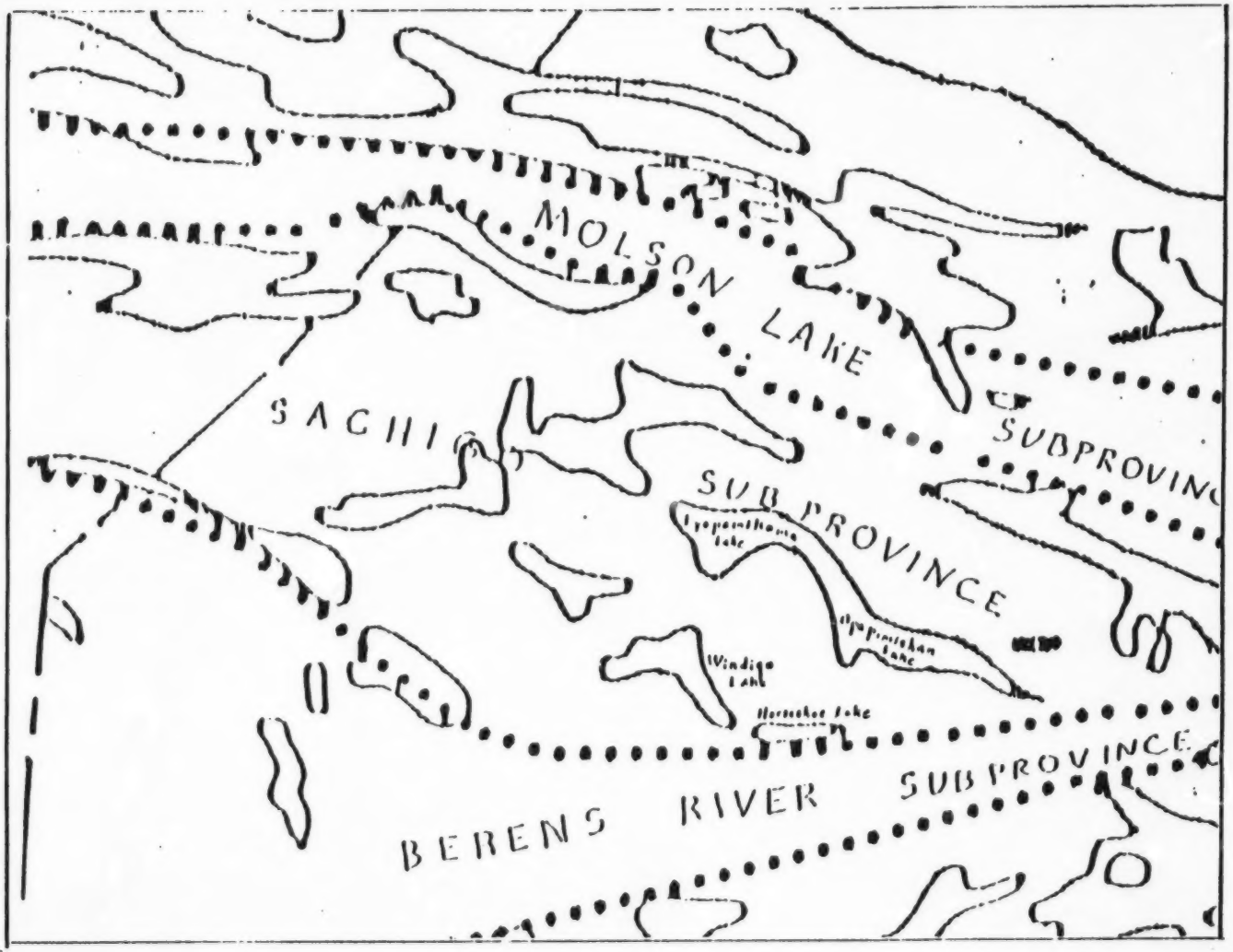
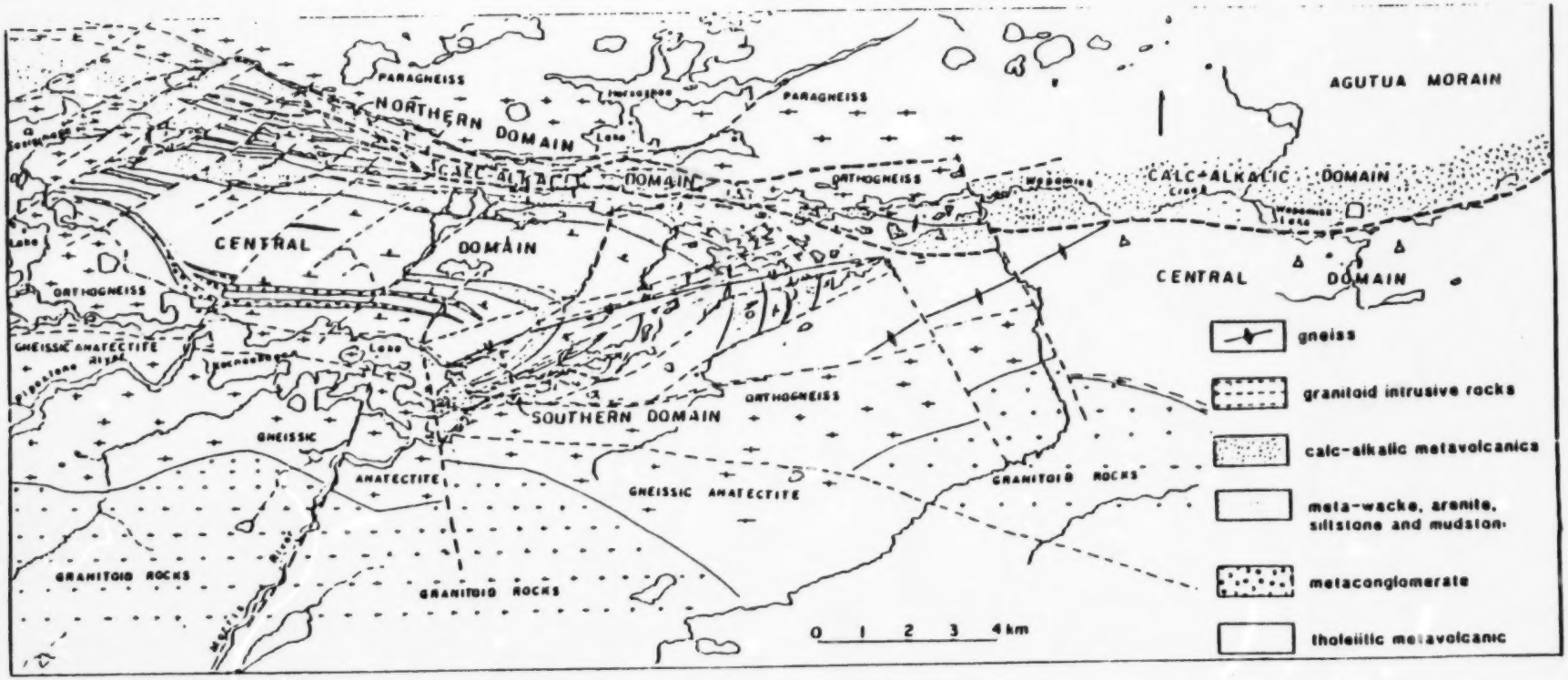


Figure 2: Sachigo and adjoining subprovinces.



--- fault

bedding, top indicated by arrow (inclined and overturned)

pillow tops

schistosity

gneissosity

plunge of lineations

drag folds with plunge

anticline, syncline with plunge

axial plane with plunge

overturned fold

geological contact

domain boundary (supracrustal sequences)

domain boundary (supracrustal sequences-migmatites)

FIGURE 1: General Geology of the Horseshoe Greenstone Belt (modified after Jensen, 1987)

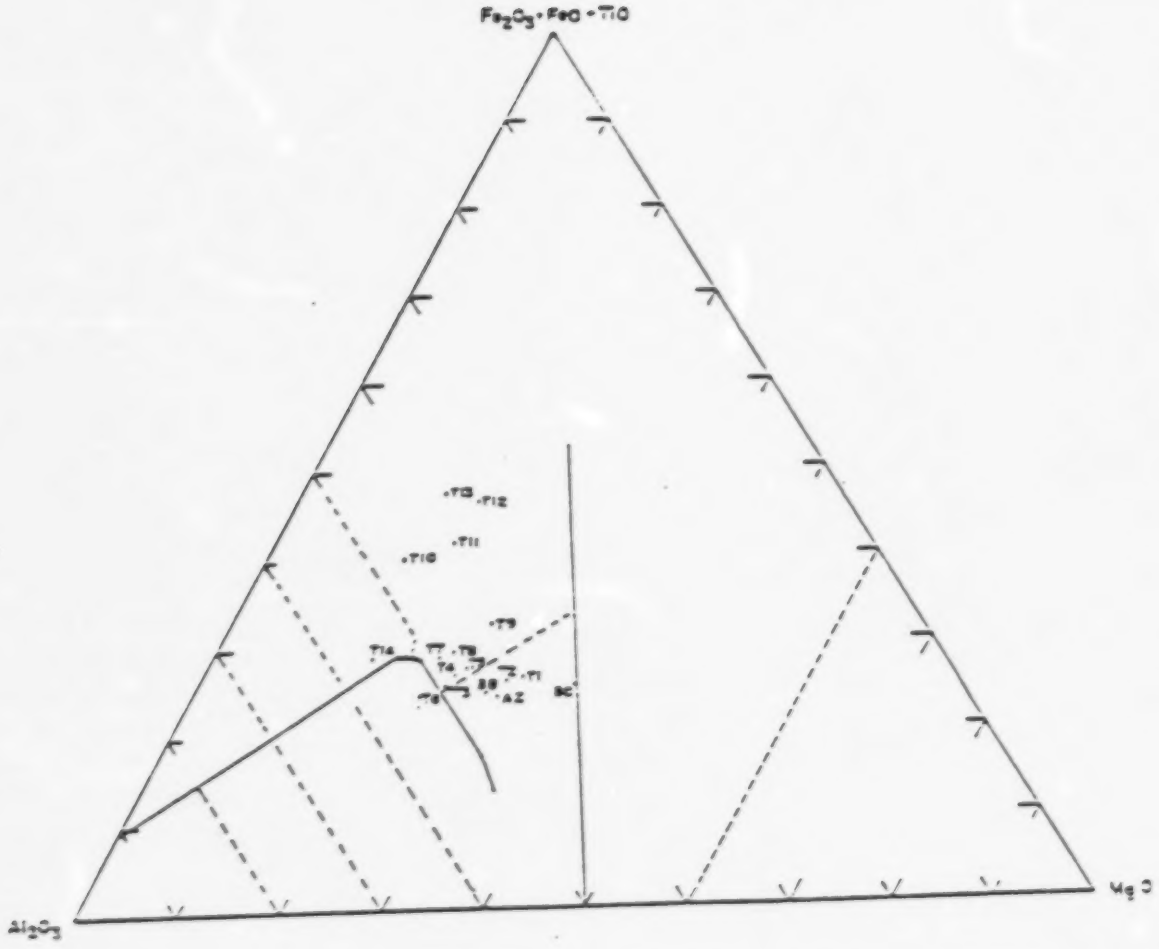


Figure 4: Projections of chemical analyses from the tholeiitic metavolcanic rocks of the Central Domain on the Jensen Cation Plot (Jensen, 1976)

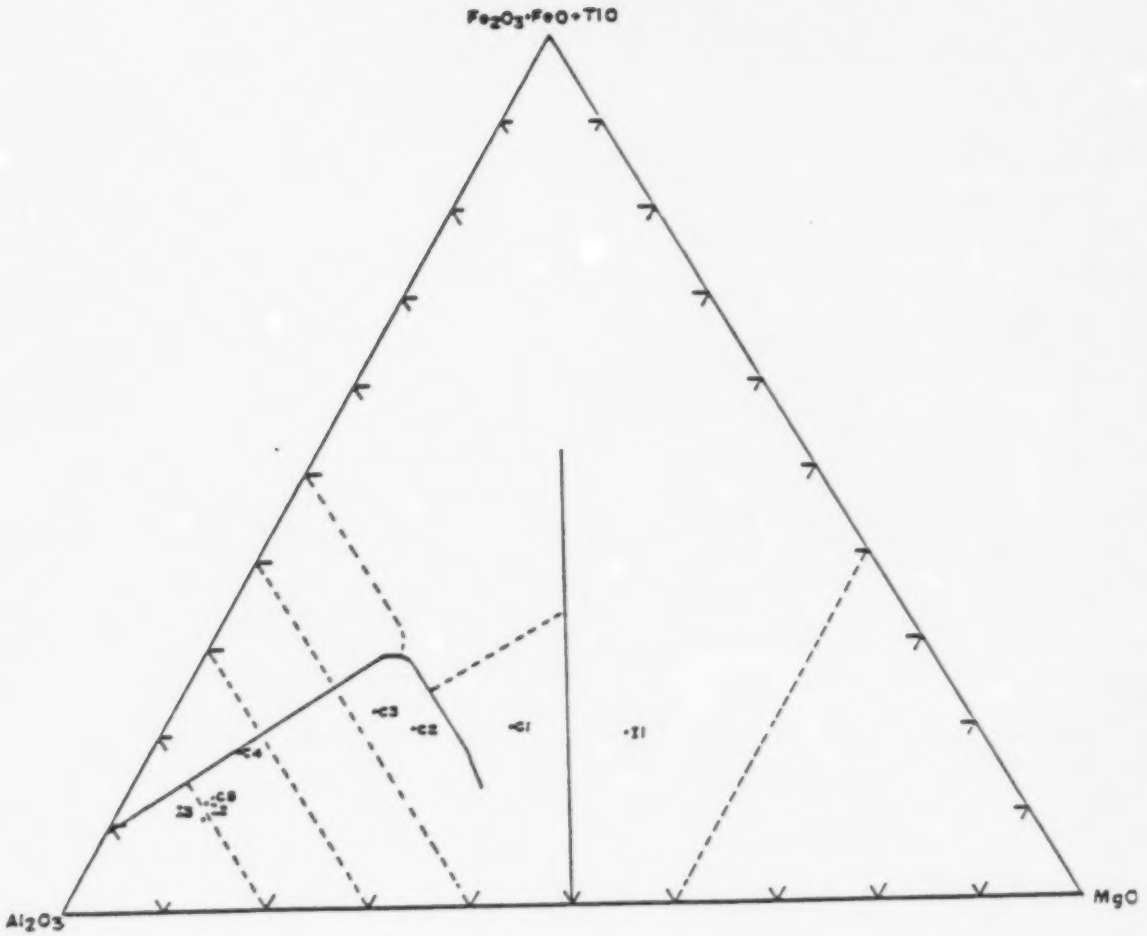


Figure 5: Projections of chemical analyses of calc-alkalic metavolcanic and subvolcanic rocks from the Calc-alkalic Domain on the Jensen Cation Plot (Jensen, 1976).

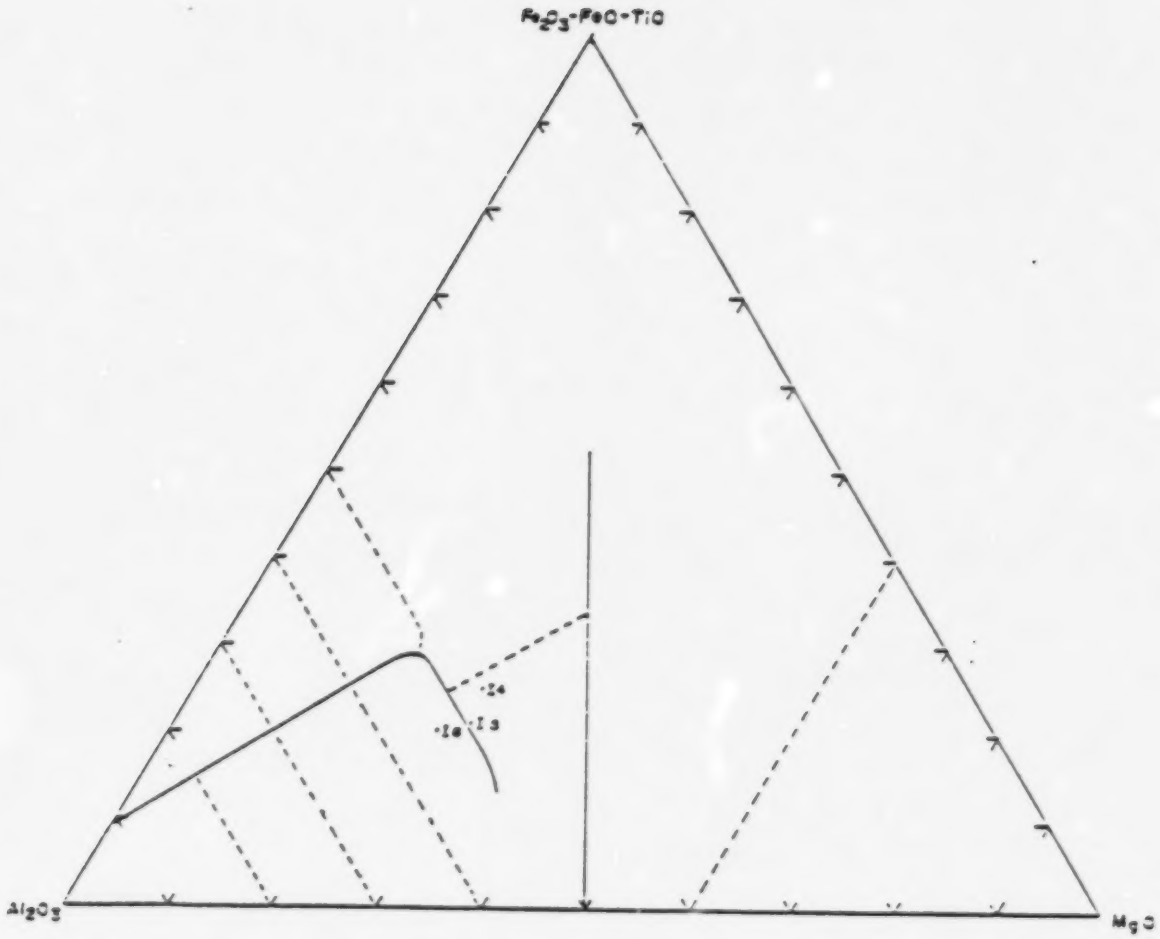


Figure 6: Projections of chemical analyses from mafic dikes that intrude the metavolcano-sedimentary succession of the Central Domain on the Jensen Cation Plot (Jensen, 1976).

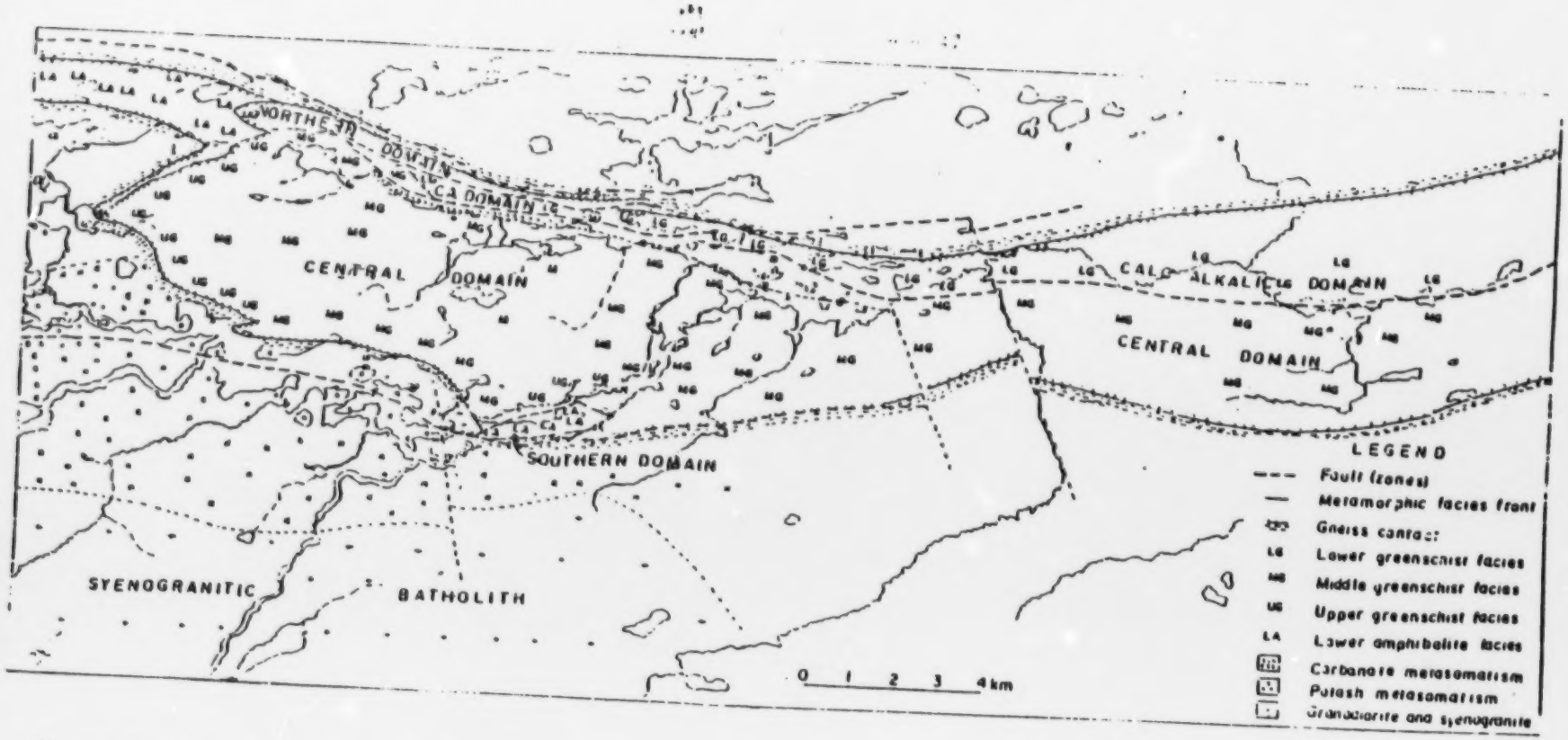


Figure 7: Distribution of metamorphic facies and metasomatism in the Horseshoe Lake Area.

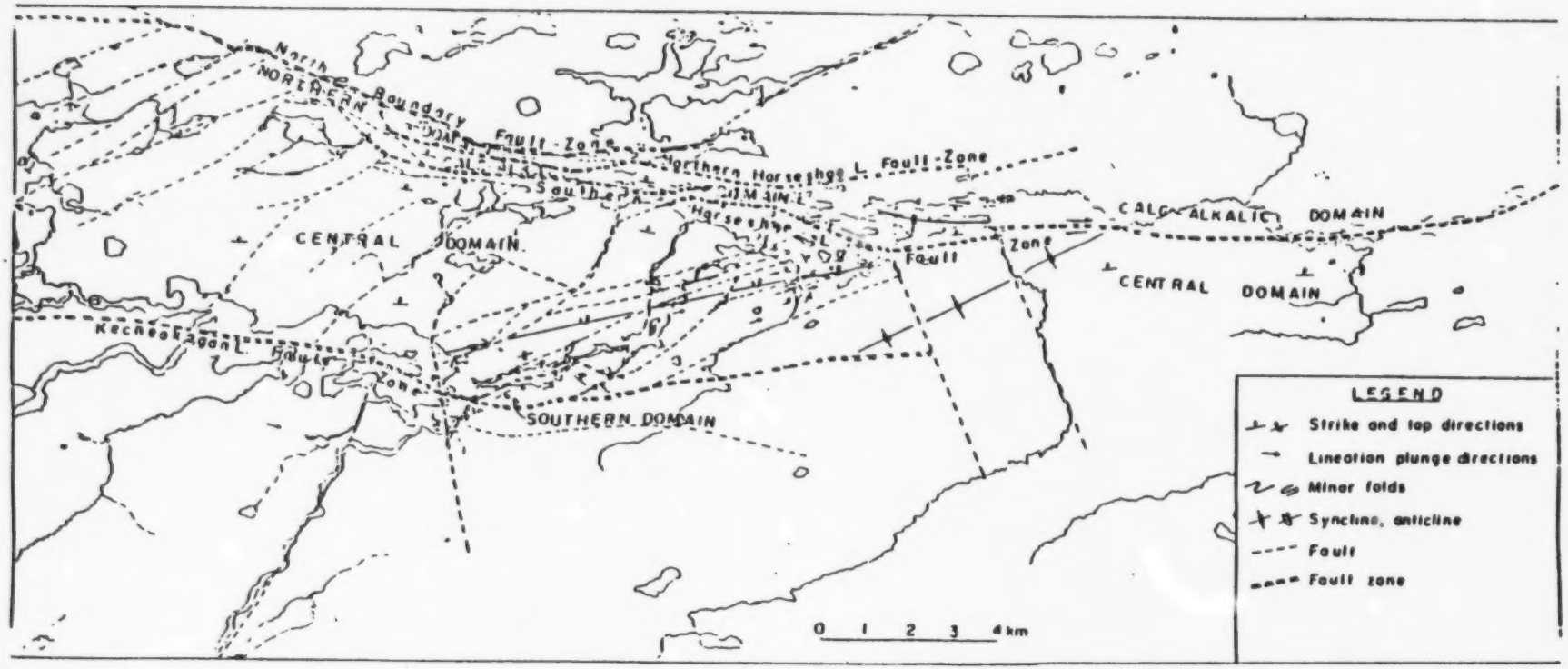


Figure 8 : Structural geology of the Horseshoe Lake Area.

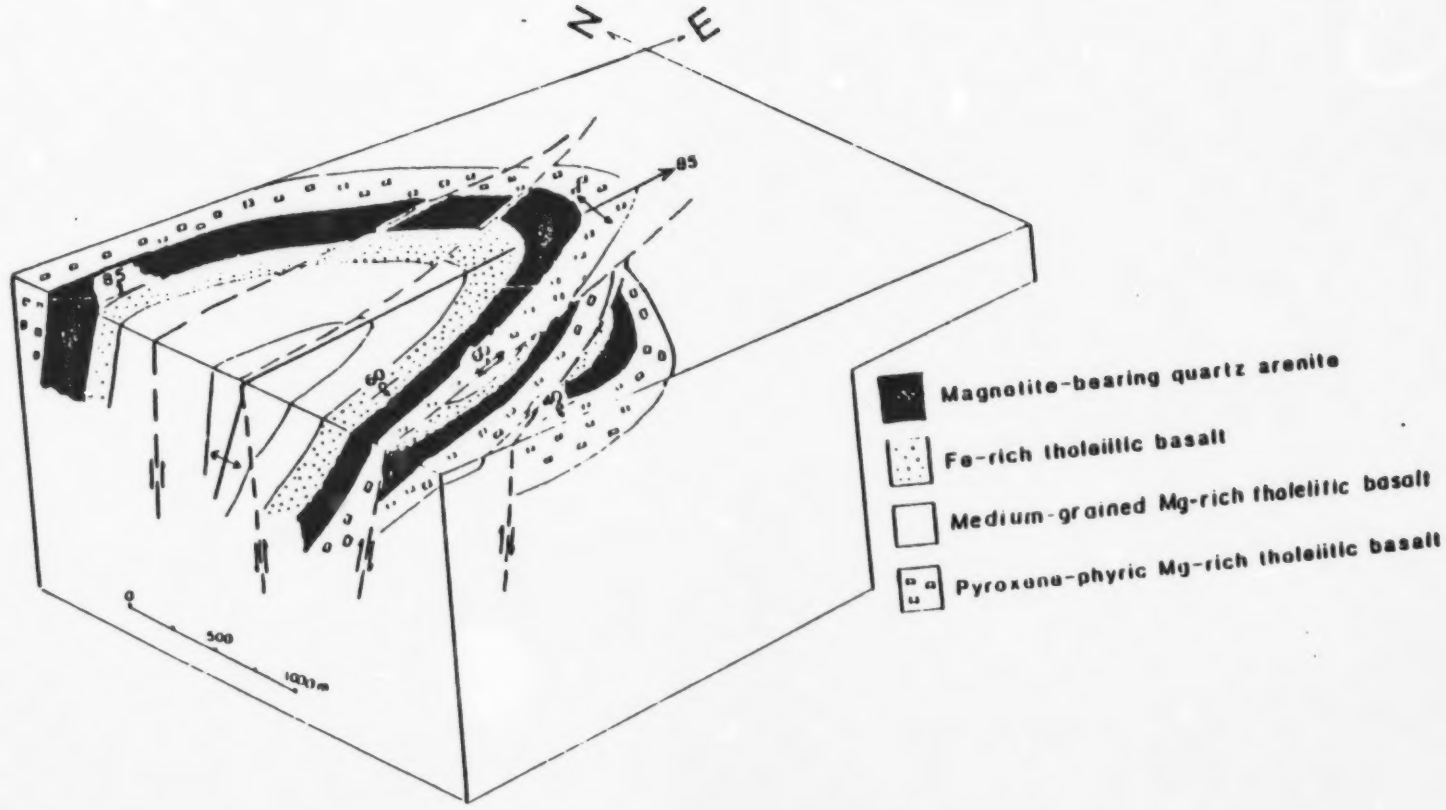


Figure 9 : Reverse faulting and the repetition of strata in the south limb of the anticline in the Central Domain.

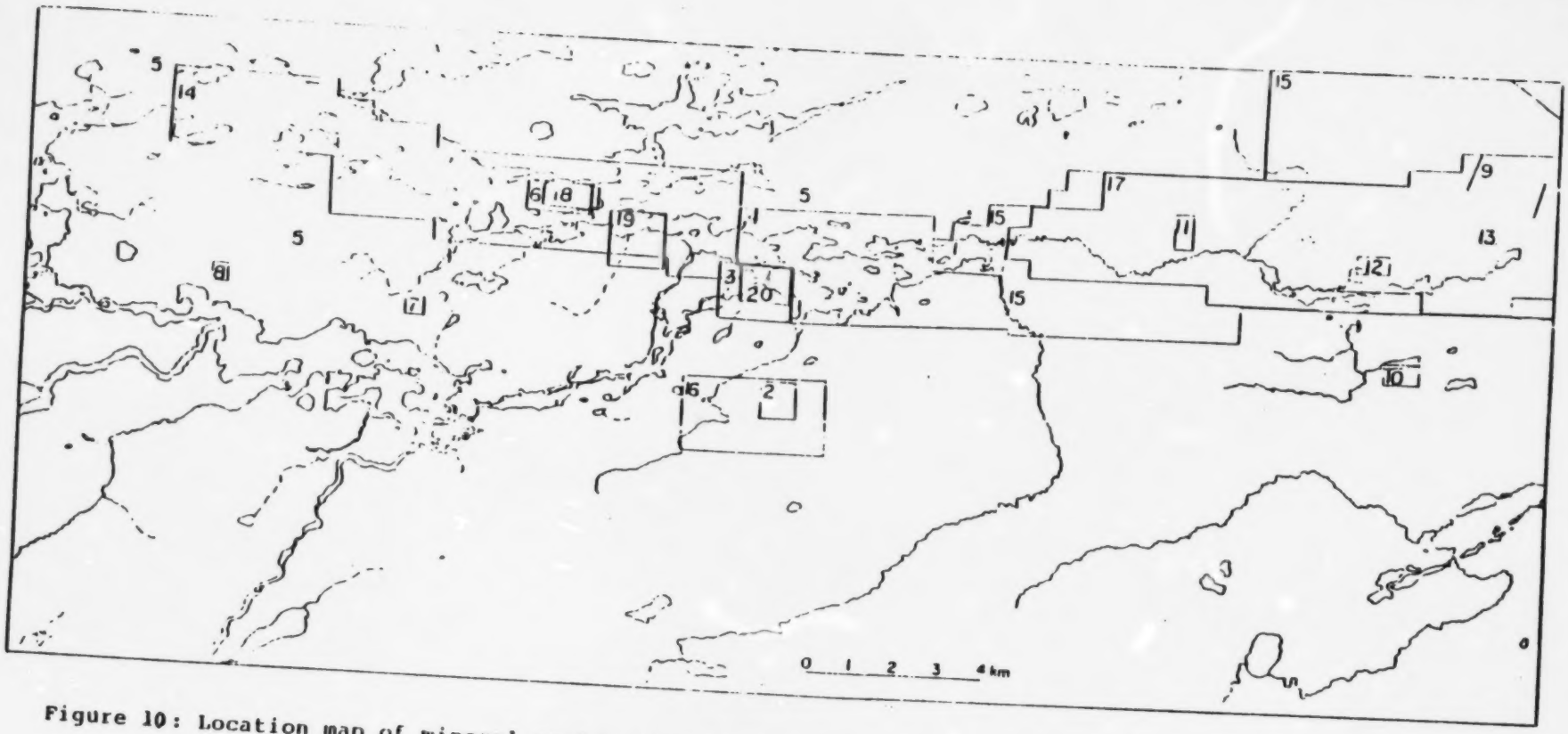


Figure 10: Location map of mineral exploration in the Horseshoe Lake Area.

1. Canadian Occidental Petroleum Limited
2, 3, 4. Dome Exploration (Canada) Limited
5, 6, 7, 8, 9, 10. Great Plains Development Company of Canada Limited
11, 12, 13, Greenstrike Gold Corporation
14, 15, Norcen Energy Resources Limited
16. 581356 Ontario Limited
17. Petromet Resources Limited
18, 19, 20. Rio Tinto Canadian Exploration Limited

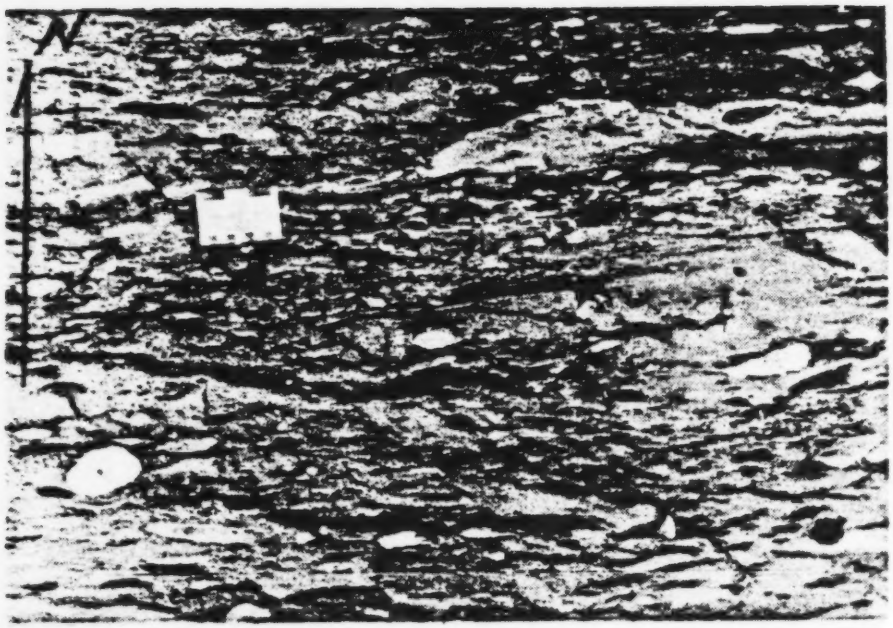


Photo 1. Upper Conglomerate Unit with channel scouring and filling.

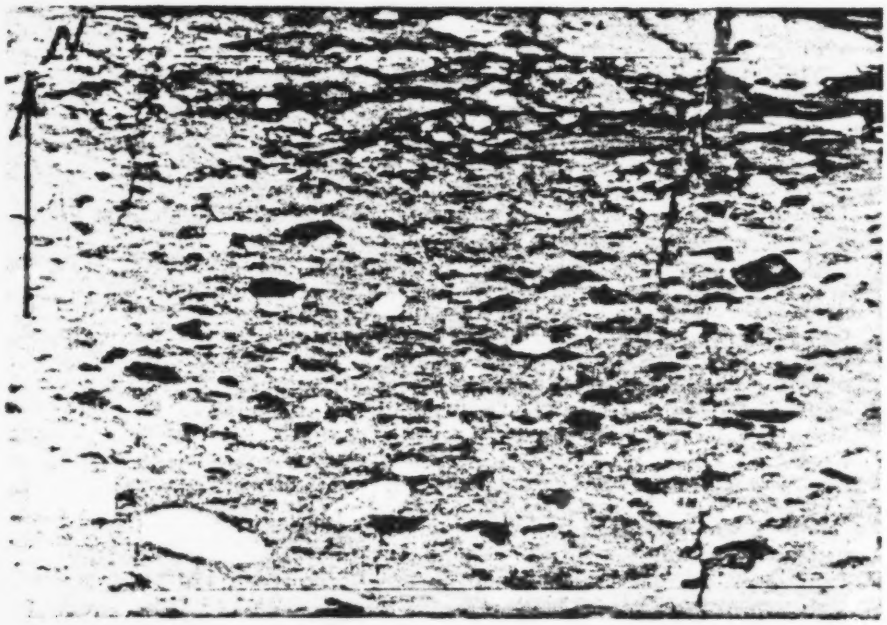


Photo 2. Upper Conglomerate Unit with rhyolite, basalt, and rip-up clasts.

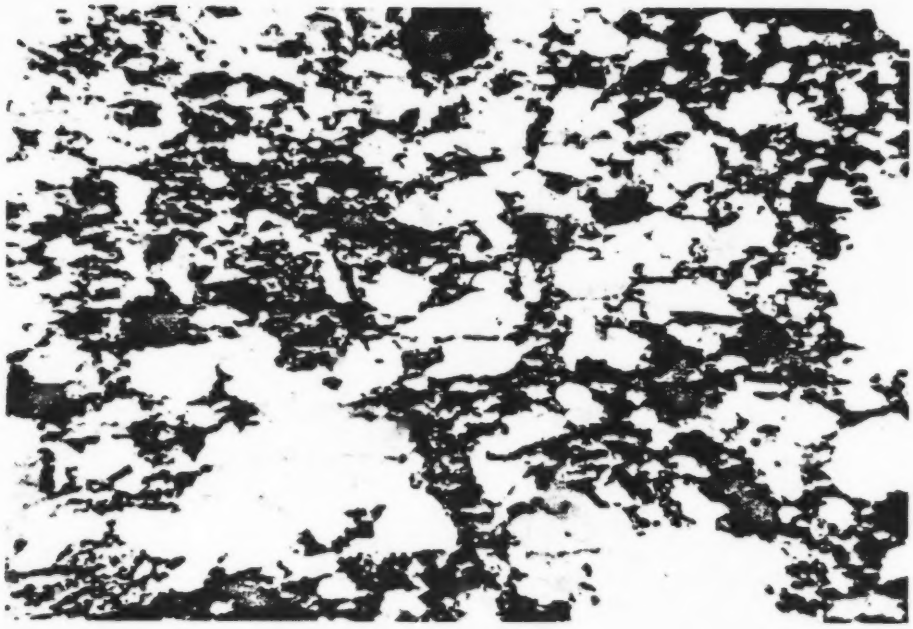


Photo 3. Photomicrograph of quartz-rich metawacke under crossed polarized light. (approximate scale 2.5 cm = 1 mm)

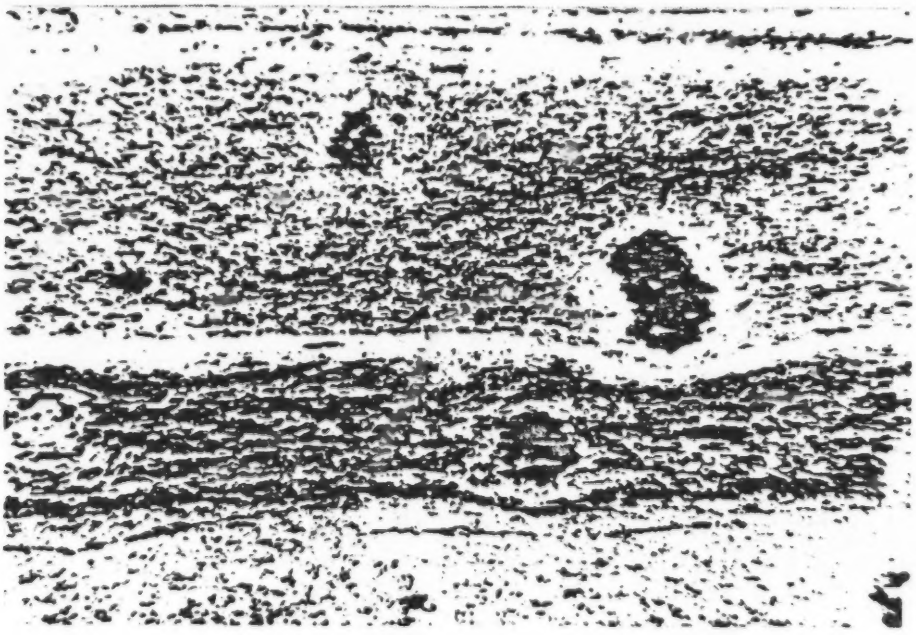


Photo 4. Photomicrograph of bedded metamudstone with sericitic pseudomorphs after chloritoid, or possibly cordierite, under crossed polarized light. (approximate scale 2.5 cm = 2 mm)

Photo 5. Photomicrograph of magnetite-rich metawacke under plane polarized light. (approximate scale 2.8 cm = 1 mm)

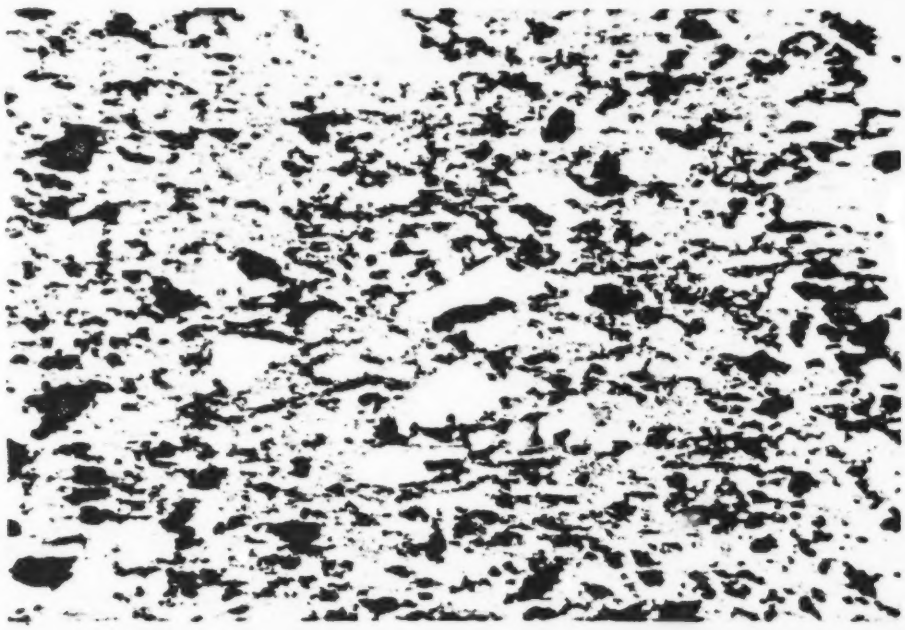


Photo 6. Photomicrograph of fuchsite-rich metasiltstone under crossed polarized light. (approximate scale 2.5 cm = 1 mm)

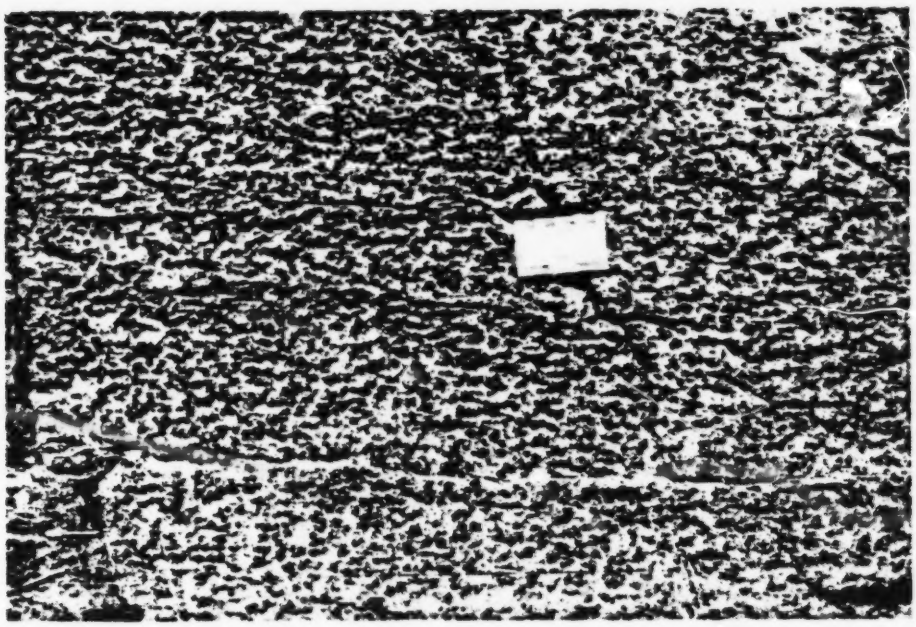


Photo 7. Pyroxene-phyric Mg-rich tholeiitic metabasalt flow north of Kecheokagan Lake.

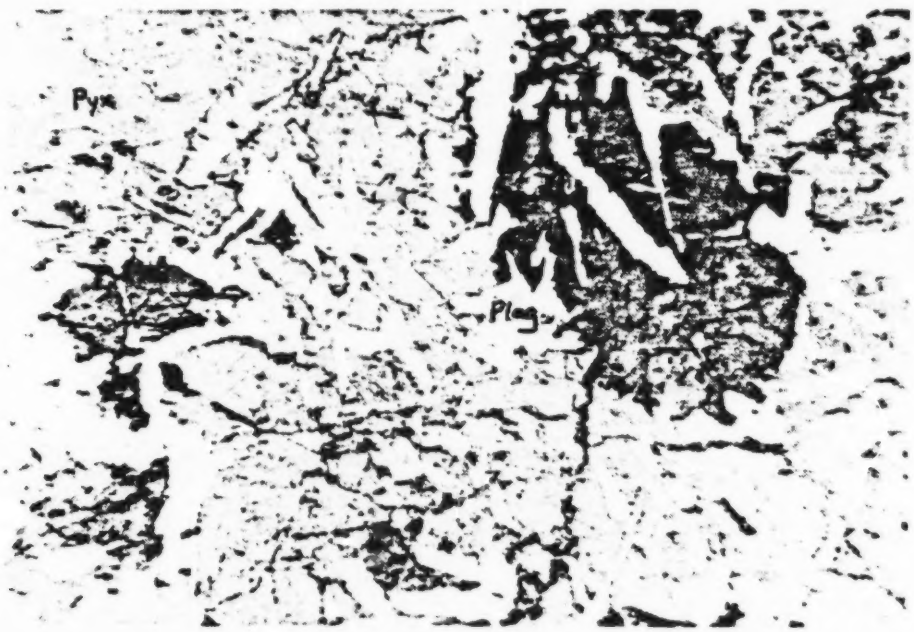


Photo 8. Pyroxene-phyric Mg-rich tholeiitic metabasalt under plane polarized light. (approximate scale 1.3 cm = 3 mm)

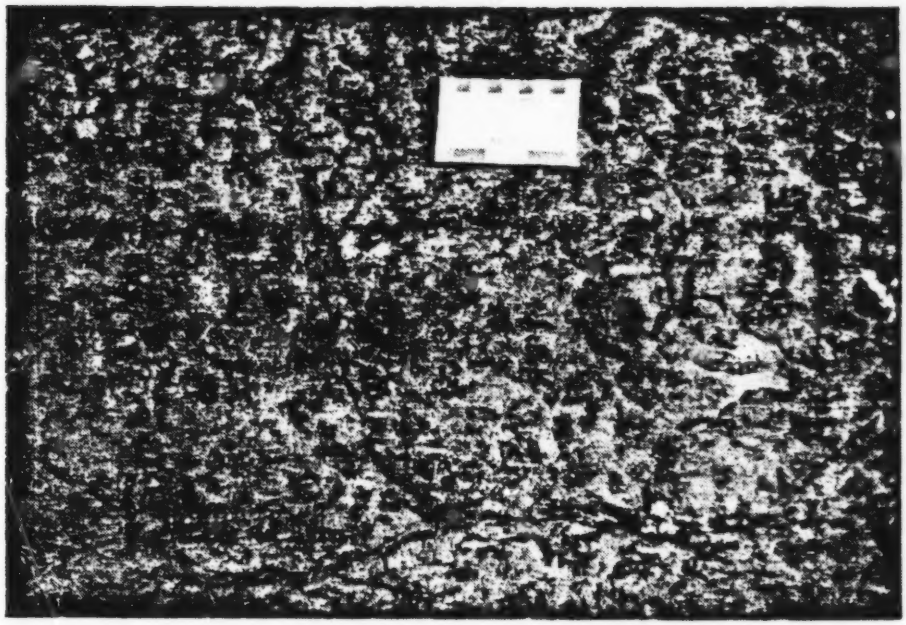


Photo 9. Mg-rich tholeiitic metabasalt comprised of tightly packed, 1 to 3 cm sized pyroxene phenocrysts.

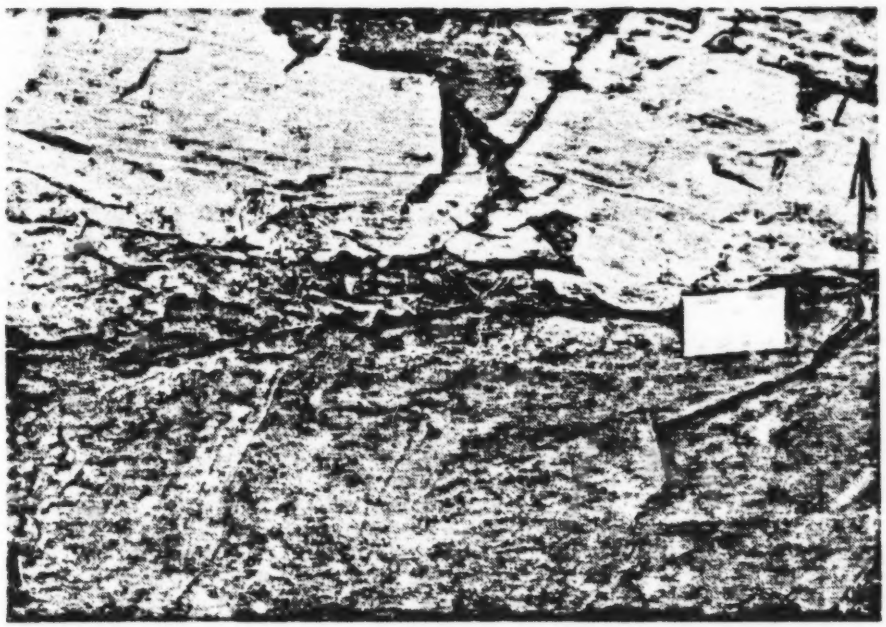


Photo 10. Metasedimentary rocks disconformably overlying fine-grained Mg-rich tholeiitic basalt which grades down into pyroxene-phyric metabasalt.

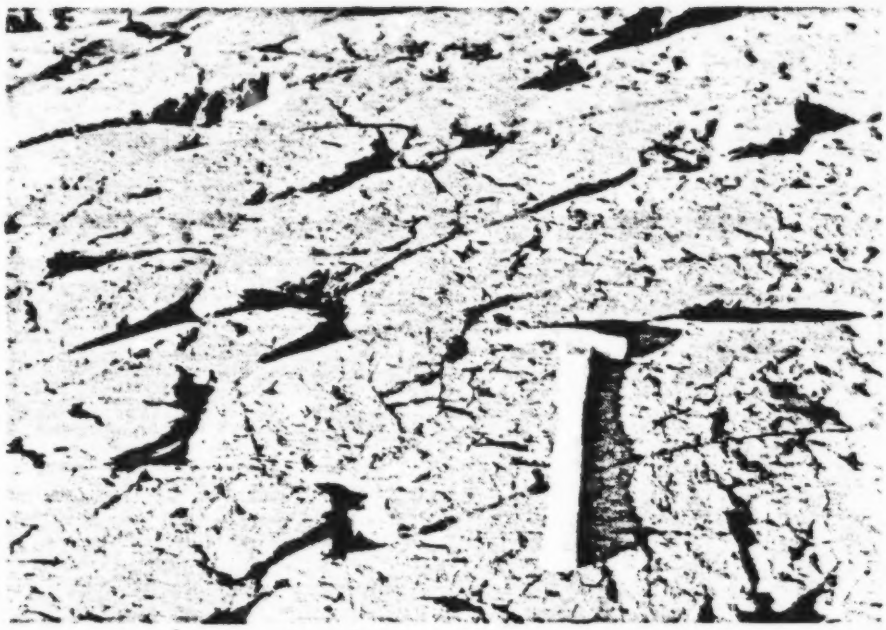


Photo 11. Pillowed calc-alkalic metabasalt along the north shore of S.E. Horseshoe Lake.

Photo 12. Bedded tuffs of calc-alkalic andesite composition on the north shore of S.E. Horseshoe Lake.

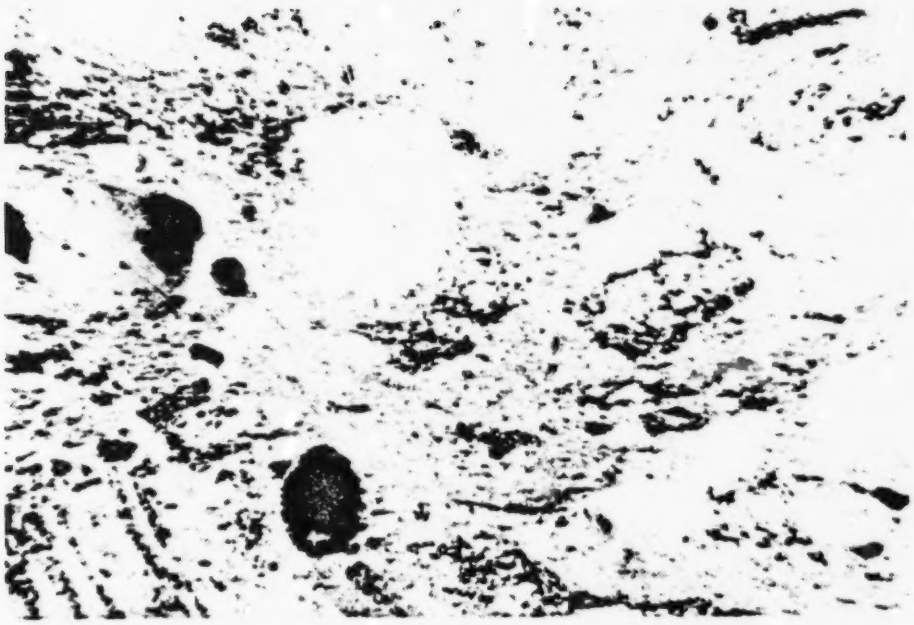


Photo 13. Photomicrograph of calc-alkalic dacite crystal tuff under crossed polarized light. (approximate scale 2.5 cm = 2 mm)

Photo 14. Photomicrograph of calc-alkalic subvolcanic quartz-plagioclase porphyry dike under crossed polarized light. (approximate scale 2.5 cm = 2 mm)

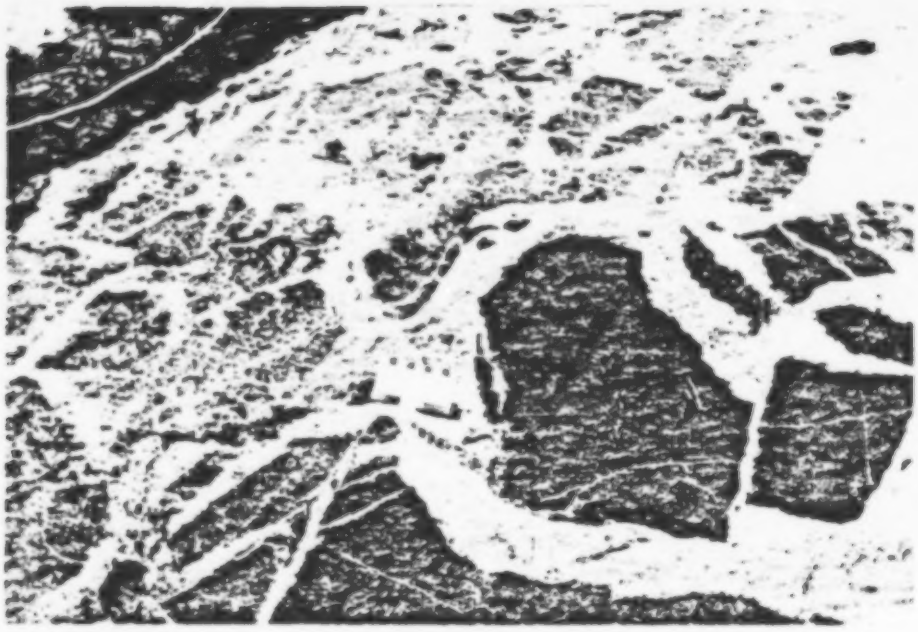


Photo 15. Xenoliths of pyroxene-phyric Mg-rich tholeiitic metabasalt in leucosome of the gneissic granitoid anatectites south of Kechokagan Lake.

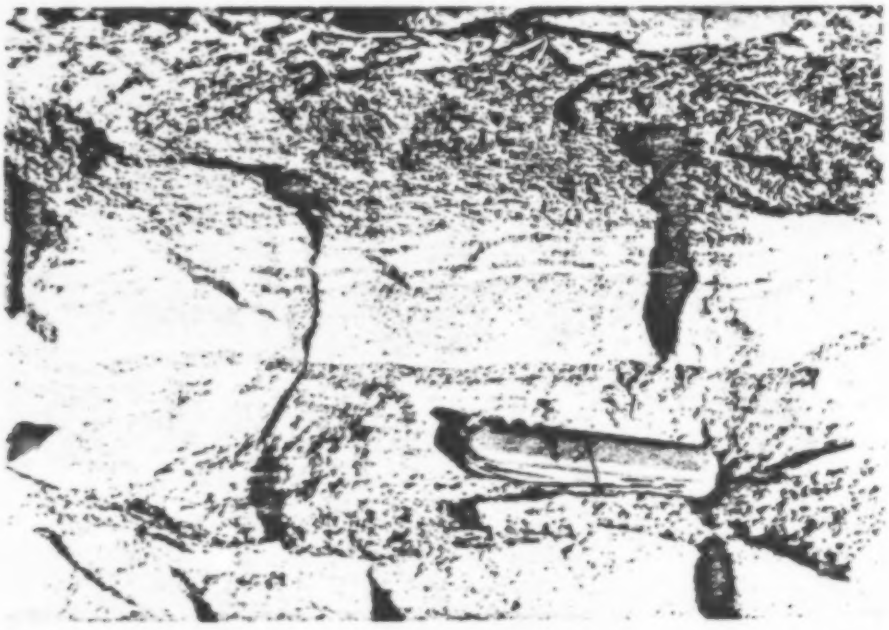


Photo 16. Overturned graded metawacke bed on the south limb of the anticline along the Pipestone River east of Kecheokagan Lake.

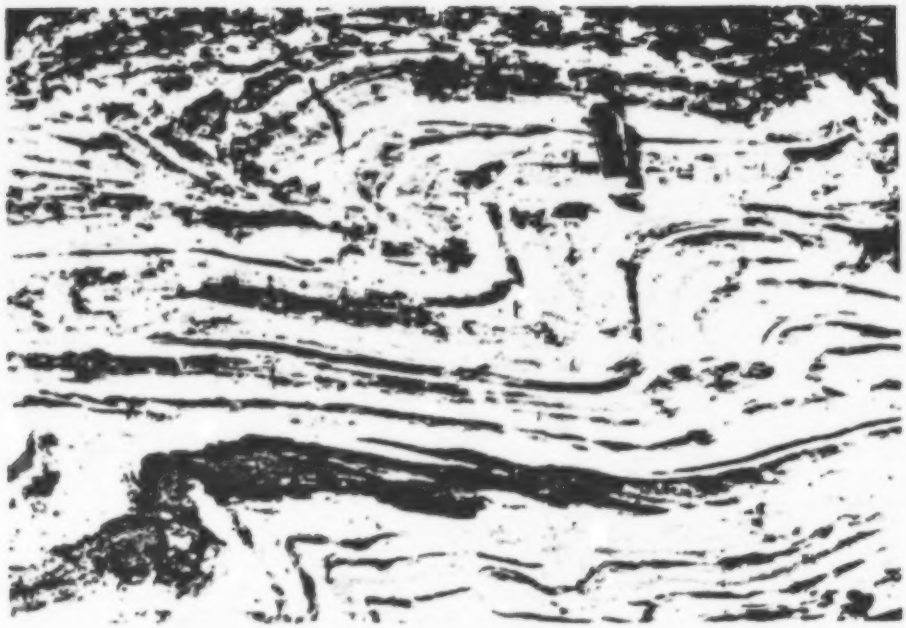


Photo 17. Parasitic folding and fracturing of the meta-sedimentary rocks near the axis of the anticline along the Pipestone River.

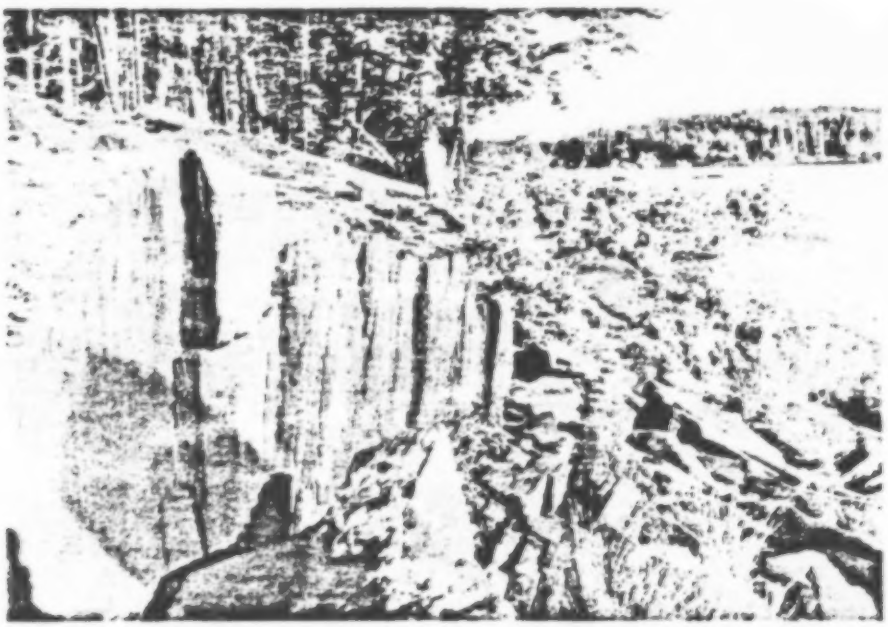


Photo 18. Sheared calc-alkalic metatuff along the South Horseshoe Lake Fault Zone on the north shore of S.E. Horseshoe Lake.

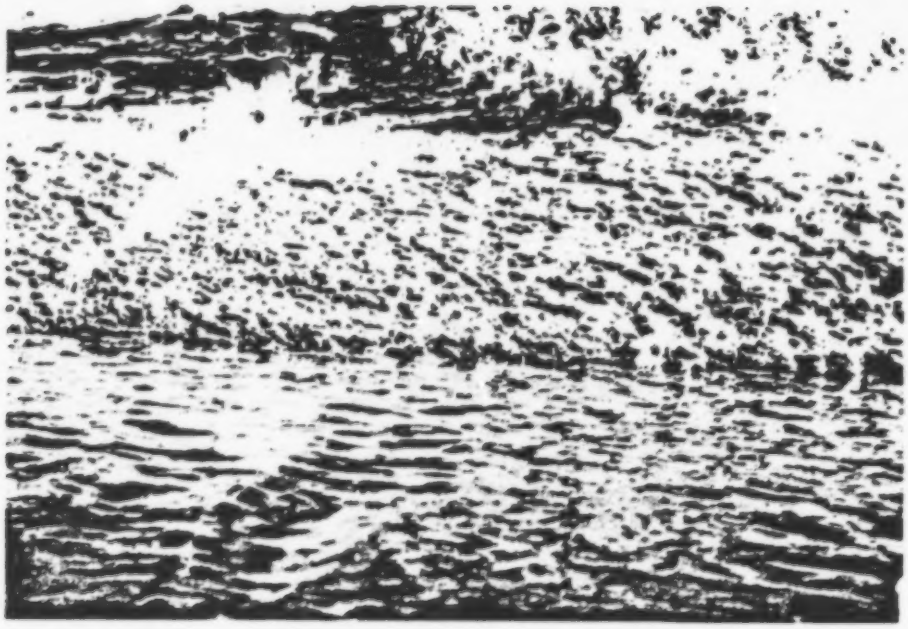


Photo 19. Sheared tholeiitic metabasalt along the North Horseshoe Lake Fault Zone on the shore of central Horseshoe Lake.

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ISSN 0826-9580
ISBN 0-7729-5116-0

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